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INVOLVEMENT OF THE SPINAL CORD BY INTERVERTEBRAL DISK PROTRUSIONS

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ALTHOUGH during the past twenty years much has been written concerning intervertebral disks, reports dealing with protrusions of these structures affecting the spinal cord have been relatively infrequent. Attention has naturally been focused upon the extremely common protrusions placed laterally in the lumbar or cervical canal where they usually affect but one spinal nerve and produce spinal and root pain. Protrusions situated so as to involve the spinal cord are by comparison very uncommon (*Table I*). However, since their effects are so much more serious than those of the lateral protrusions, and since they occur in significant percentage in any series of cases of spinal cord compression, the importance of these medially situated protrusions is clear. This paper is based upon a personal experience of them during the last fifteen years in the Department of Neurological Surgery of St. Bartholomew's Hospital. It must be emphasized that the term intraspinal protrusion of an intervertebral disk implies that a mass of disk tissue, small or large, has escaped into the spinal canal; it is composed of the two parts of the disk—nucleus pulposus and annulus fibrosus; while secondary pathological change may occur in both the protrusion itself and in the joint from which it has escaped, the essential lesion is a circumscribed space occupying one composed of intervertebral disk tissue. These cases must therefore be clearly distinguished from those of spondylosis in which the essential changes in the intervertebral joints are degenerative and in which multiple joints are usually involved. Though it is now well recognized that spinal cord involvement may occur in cases of spondylosis in the cervical region such cases must not be confused with those of intervertebral disk protrusion and the present paper is not concerned with cases of spondylosis.

Intervertebral disk protrusions occurring in relationship with the spinal cord produce neurological disturbance in two distinct ways. In the first place the cord may be concussed, contused, or lacerated by an acutely developing protrusion and the clinical picture is the result of this trauma. Secondly, a more gradually developing protrusion may give rise to the picture of increasing cord compression. While it seems likely that traumatic and compressive factors combine to produce the clinical picture in certain cases it is believed that the subject is clarified by the separate consideration of the two groups. In the pages which follow examples of syndromes of spinal cord injury due to intervertebral disk protrusions will first receive consideration. Then cord compression by intervertebral disk protrusions will be discussed and the records of fourteen such cases treated surgically analysed.

Table I.—INCIDENCE OF SPINAL CORD COMPRESSION BY INTERVERTEBRAL DISK PROTRUSIONS

A. Cases of spinal cord compression treated surgically

1. Compression from all causes		133
2. Compression by intervertebral disk protrusions		14 (10·5 per cent)

B. Cases of intervertebral disk protrusion treated surgically

1. Median protrusions:	Cervical	8	
	Thoracic	4	
	Lumbar	8	(6 below conus medullaris)
	Total	20	
2. Lateral protrusions:	Cervical	3	
	Thoracic	0	
	Lumbar	927	
	Total	930	

Of 950 surgically treated protrusions, 14 involved the spinal cord (1·5 per cent).

I. TRAUMATIC LESIONS OF THE SPINAL CORD OCCASIONED BY INTERVERTEBRAL DISK PROTRUSIONS

The injuries to the spinal cord due to intervertebral disk protrusions which have been encountered have occurred in the cervical canal and the cases fall into two groups. First there is the group in which following an injury to the head and cervical spine evidence of a cord lesion appears; secondly there is that in which in the absence of any injury to the head, and as a result of some postural stress, a lesion of the cervical cord develops acutely. The two will now be considered briefly and separately.

It is generally recognized that following an injury to the cervical spine evidence of a severe and perhaps total transverse lesion of the cervical cord may arise and yet radiological examination of the spine shows no evidence of fracture or dislocation. To explain the cord injury in these cases it had been suggested that it was due to a transient and spontaneously

reducing anterior dislocation of one segment of the cervical spine on that below. This view was accepted although evidence in favour of it had been lacking. Cramer and McGowan (1944) described a case of complete transverse lesion of the cervical cord at the fifth cervical segment, the result of injury to the neck. Radiography revealed a mild degree of compression of the fifth cervical vertebral body with narrowing of the interval between this body and that beneath it. At autopsy it was found that there was a posterior protrusion of the disk between these vertebræ into the spinal canal for 4 mm. At this level the cord had been severed apart from the posterior columns and the membranes covering them. The authors considered that the changes found in this case, as well as those described in autopsy reports in the literature dealing with so-called recoil injuries of the spinal column, point clearly to the intervertebral disk as the agent responsible for the cord injury and they express the view that the spontaneous reduction of a dislocation unassociated with fracture would be unlikely to occur. Barnes (1948) also refers to the lack of correlation between the severity of the cord injury and the vertebral displacement and finds that dislocation of a neural arch can compress the spinal cord only when at least one pair of articular processes has locked. He therefore considers that unless there is clear radiographic evidence of fracture of the articular processes, such as would permit spontaneous reduction of a dislocation, some alternative explanation of the cord injury must be sought. He discusses other mechanisms by which the neural damage can be produced and has found it to be due to an acute cervical disk protrusion in three cases. In 1941 the first case of this type was admitted to the Neurosurgical Department of St. Bartholomew's Hospital and the records of this patient will now be summarized.

A 62-year-old woman was walking in the blackout to an air-raid shelter when she tripped and fell striking her head against a wall. She experienced immediate cervical pain with complete loss of power in all her limbs, numbness of the trunk and tingling in the hands and feet. Examination in hospital thirty minutes later revealed a transverse frontal scalp laceration, a tetraparesis of severe degree with reduced sensibility and loss of sphincter control. When examined in the neurosurgical department four days later there was found to be pain on cervical flexion and tenderness over the lower cervical spines. There was paralysis of the upper limb muscles below those supplied by the 5th cervical segment with a severe spastic weakness of the lower limbs. There was analgesia and thermo-anæsthesia below the 5th cervical dermatome with a loss of vibration sensibility below the acromion processes and reduction in postural sensibility, greater in the upper limbs. The tendon reflexes were weakly obtained, apart from the supinator jerks, the abdominal reflexes were absent and the plantar responses extensor. Vesical and rectal function remained involuntary. Radiography of the cervical spine showed no abnormality other than a possible chip fracture of the antero-inferior angle of the 3rd cervical vertebra. Lumbar puncture showed no block and the cerebrospinal fluid no abnormality other than a protein of 65 mg. per 100 ml. The neurological picture improved somewhat until the occurrence of a pulmonary embolism which was followed by death 26 days after the injury. Autospy revealed bilateral femoral thromboses with an embolus at the bifurcation of the pulmonary artery. A protrusion of the intervertebral disk between the 5th and 6th cervical vertebræ was found. Softening of the spinal cord had occurred at this level. Histological examination showed degeneration in the posterior and lateral columns with demyelination and phagocytosis of fat by histiocytes.

At times the evidence of a cervical cord lesion secondary to a head injury is less severe. Walshe and Ross (1936) and Walshe (1944) discuss a group of cases in which evidence of such a lesion becomes obvious during convalescence from a head injury. The picture in these cases was one of a lesion of the 5th cervical segment with a spastic tetraparesis varying in severity from case to case, and absent sensory and sphincter disturbance. In the lower limbs there was hyper-reflexia with extensor plantar responses and in the upper a normal biceps, exaggerated triceps, and inverted supinator jerk. The authors had no autopsy material from which to determine the mechanism of production of the cord lesion and suggest as a possibility that the cervical cord is stretched over the posterior surfaces of the vertebral bodies when the neck is forcibly flexed. In the presence of cervical spondylosis, which was seen radiographically in several of these authors' cases, the danger of such a stretching force is clearly increased because of the encroachment upon the anterior part of the spinal canal of the hypertrophic vertebral margins. A small acute disk protrusion might be expected to have a similar effect upon a cervical cord tensed by flexion of the neck. No personal cases of this type, in which the early clinical picture is that of a head injury, has been submitted to operation or come to autopsy. However, two cases of proven acute cervical disk protrusion producing cord injury have been encountered (*Cases* 1 and 8). In both the effects of the cord injury had largely passed, but evidence of cord compression necessitating operation subsequently developed.

In the foregoing cases the spinal cord lesion and the intervertebral disk protrusion which caused it resulted from a definite injury to the cervical spine. It would appear that the cervical cord may be suddenly traumatized without any definite injury to the spine and here again it seems that an intervertebral disk protrusion may be the agent responsible for the injury. There follows a summary of the record of such a case.

A 63-year-old woman was admitted complaining of pain in the back of her neck and weakness of her right side. Two weeks previously while reaching upwards to place a jar on a shelf she developed pain in the back of her neck spreading to both shoulders. The pain was severe and caused her to retire to bed where, within thirty minutes, she became aware of weakness of her right side. She was admitted to another hospital where she had retention of urine for twenty-four hours. The cervical pain lessened and tingling in the right thumb appeared. Lumbar puncture showed no block and a cerebrospinal fluid protein of 85 mg. per 100 ml. When admitted to the neurosurgical department two weeks after the onset of her symptoms there was tenderness over the lower cervical spines and slight limitation of cervical movement by pain. There was a paresis of the right limbs, more marked distally, extending proximally to mildly involve abduction of the shoulder with gross weakness of finger, wrist, toe, and ankle movement. There was reduced pain, temperature, and touch sensibility below the 4th

thoracic dermatome on the left with an area of hyperalgesia between the 6th cervical and the 3rd thoracic dermatomes (inclusive) on the right side. There was no disturbance of sense of position or vibration, the only reflex abnormality being exaggerated tendon reflexes in the right leg with an extensor plantar response. Radiography showed narrowing of the interval between the 6th and 7th cervical vertebræ. Lumbar puncture again revealed no block and the cerebrospinal fluid protein had fallen to 30 mg. per 100 ml. Myelography was not informative, since the column broke into globules, and simply excluded the presence of a large space occupying lesion. The patient's condition underwent spontaneous improvement and when discharged after three weeks cervical mobility was free and pain absent, there being no longer a demonstrable weakness of the arm, though weakness of the ankle still affected gait. The sensory loss on the left persisted. She was re-examined ten months later and she was still aware of stiffness of the right leg and numbness of the left. The signs were limited to a slight spasticity of the right leg and peripheral reduction of cutaneous sensibility on the left with normal plantar responses. The Brown-Séquard syndrome exhibited by this patient points clearly to a lesion limited to the right anterolateral column of the spinal cord, and the root pain suggests that this lesion was at the level of the 6th cervical segment. Further the acute onset of the symptoms with cervical pain during postural stress points to a traumatic vertebral lesion as the cause—and the most probable such lesion is a small disk protrusion.

These observations provide further evidence that severe injury to the cervical cord may be occasioned by an acutely developing intervertebral disk protrusion of traumatic origin. They further suggest that in certain other cases of suddenly developing, but less severe, lesions of the cervical cord, an intervertebral disk protrusion is the causative agent. In this latter group the protrusions will frequently be the result of stresses in the cervical spinal column occasioned by the application of external force, especially in head injury; occasionally, however, the protrusion may be spontaneous—that is, the result of postural stress and muscular action.

II. COMPRESSION OF THE SPINAL CORD BY INTERVERTEBRAL DISK PROTRUSIONS

Before the nature of protrusions of the intervertebral disks was recognized these lesions were regarded as chondromata and occasional reports of spinal cord compression by such tumours have appeared since early in the present century. The first important contribution to the literature was that of Stookey who in 1928 described seven cases of what he termed ventral extradural chondromata occurring in the cervical canal. In three of these patients the position and size of the mass were such that the whole of the spinal cord at its level was affected; in three the relationships were such that a Brown-Séquard syndrome arose and in one the lateral position of the mass permitted root involvement alone. Stookey pointed out that manometry may reveal only a partial subarachnoid block and that the flow of iodized oil introduced into the theca may not be obstructed by the lesion. He mentions that the results of surgery in this group of tumours are not encouraging. Elsberg (1931) described a series of fifteen ventral extradural chondromata—9 cervical, 2 dorsal, and 4 lumbar. He stated that they infrequently produced a subarachnoid block and that the cerebrospinal fluid protein was elevated to a less extent than with other types of tumours. Hawk (1936) reviewed the literature dealing with 58 cases of what he termed ecchondroses of the intervertebral fibro-cartilage and added 10 cases—1 cervical, 4 dorsal, and 5 lumbar. Subarachnoid block was present in 75 per cent of his series, complete in 25 per cent, and the cerebrospinal fluid protein was increased in 80 per cent. Osteo-arthritic changes were revealed in the spine by radiological examination in several cases with narrowing of intervertebral disks and occasional calcification in them. He states that as a result of operation 30 per cent of his cases were improved, 20 per cent unchanged, and 50 per cent worse.

By 1930 the studies of Schmorl on the pathology of the intervertebral disk had been published and reports of the surgical excision of herniations or protrusions of disk tissue had begun to appear. The work of Mauric (1933) in France and of Mixter and Barr (1934) in the United States was of particular importance in indicating that such protrusions were the underlying cause in some cases of that very common symptom sciatica, a relationship which suggested that disk protrusions themselves might be common lesions. This of course proved to be the case and during the last twenty years the literature dealing with the subject has become enormous. However, as previously indicated, much of it deals with protrusions producing radicular pain and papers concerned with cases in which cord compression had occurred have been relatively infrequent. Some of the more important of the latter which have appeared since the true nature of these cartilaginous masses was recognized will now be briefly reviewed.

Kahn (1947) described two cases of cervical cord compression produced by intervertebral disk protrusions and pointed out that the clinical picture might be confused with that of primary lateral sclerosis. Bucy, Heimburger, and Oberhill (1948) described four cases of cervical cord compression occasioned by median disk protrusions. They discuss the clinical picture and note that the mild sensory changes, absence of manometric block, the few symptoms pointing to the cervical spine and upper limbs as well as the normal spinal rœntgenograms may lead to a diagnosis of multiple sclerosis, primary lateral or amyotrophic lateral sclerosis. Myelography will, however, usually reveal the lesion and the author's four patients did well after operation. Muller (1951 a) describes thirteen cases of cord compression by cervical disk protrusion. The majority of these showed radiological evidence of spondylosis and myelography with air revealed the lesion in every case. The results of surgical treatment in twelve patients of the group were poor and it would appear that the author is considering patients with cervical spondylosis rather than cases of true cervical intervertebral disk protrusion. Muller (1951 b) also describes four cases of cord compression by protrusions of thoracic intervertebral disks. Like Hawk (1936) and others he records poor results from the surgical treatment of these lesions—three of his cases exhibiting an immediate post-operative complete

transverse lesion and the remaining patient subsequently developing the same picture. Love and Kiefer (1950) refer briefly to experiences with seventeen cases of thoracic disk protrusion and state that the results of surgical treatment were good only when there was no gross pre-operative neurological defect. Logue (1952) reviews a series of eleven cases of thoracic disk protrusion producing cord compression. The frequency of a rapidly developing clinical picture is pointed out and the infrequent occurrence of pain in most large series are recalled. It is therefore of interest to recall that the first report of a case of spinal cord involvement by a disk protrusion was that of Middleton and Teacher (1911) in which a protrusion of the lumbo-dorsal disk was found at autopsy to be the cause of a rapidly developing lesion of the conus medullaris.

The published work on cord compression by intervertebral disk protrusions indicates the diagnostic difficulties which may arise, the danger of the

Table II.—Analysis of Clinical Features

Case No.	Level and Side of Protrusion	Sex	Age	Length of History	Pain			Power	Subjective Sensory Disturbance	Sphincter Control
					Spinal	Root	Tract			
1	C.3–4 : R.>L.	M.	53	? 4 yr. ? 4 mth.	–	–	+	Tetraparesis (excluding L. arm)	Cold L. foot. Numb fingers. Electric-shock sensations	Rectal incontinence
2	C.4–5 : L.>R.	M.	44	9 mth.	+	+	+	Tetraparesis. Extensor spasms	Tingling hands, R. leg. Electric-shock sensations	Normal
3	C.5–6 : L.>R.	M.	44	11 mth.	+	+	–	Tetraparesis (excluding R. arm). Clonic spasms, legs	Tingling L. hand. Numbness below neck	Difficult micturition
4	C.7–T.1 : R.>L.	M.	31	10 mth.	+	+	–	Tetraplegia	Tingling ulnar margin R. arm. Numbness to axilla	Double incontinence
5	C.5–6 : R.>L.	M.	39	15 mth.	–	–	–	Tetraparesis	Numbness legs, R.→L. Numbness ulnar fingers	Precipitate micturition
6	C.5–6 : L.>R.	M.	46	3 yr.	+	+	–	Tetraparesis	Tingling R. leg → hands. Coldness feet. Electric-shock sensations	Normal
7	C.4–5 : R.>L.	F.	38	2 yr.	+	+	?	Tetraparesis	Numbness and tingling legs → arms	Urgency of micturition
8	C.5–6 : L.	M.	22	3 days	+	+	–	L. hemiparesis		Retention of urine
9	T.2–3 : L.>R.	F.	42	18 mth.	–	+	–	Paraparesis	Coldness and heaviness of legs	Precipitate micturition and defæcation
10	T.9–10 : R.>L.	F.	34	1 yr.	+	+	?	Paraparesis, R.>L.	Numbness legs, R.→L.	Normal
11	T.9–10 : L.>R.	M.	40	1½ yr.	–	+	?	Paraparesis. Extensor spasms	Numbness lower abdomen and legs. Coldness and tingling feet	Precipitate micturition
12	T.9–10 : R.>L.	M.	46	2 yr.	–	+	+	Paraparesis, R.>L.	Numbness legs, R.→L.	Difficult micturition. Rectal incontinence
13	T.12–L.1 : L.>R.	M.	47	8 mth.	+	+	–	Sl. paresis, L. leg	Tingling L. sacral distribution	Difficult micturition
14	L.1–2 : R.>L.	M.	40	10 days	+	+	–	Paralysis R. leg. Paresis L. leg	Numbness below L.2. R.>L.	Retention of urine. Fæcal incontinence

and sphincter disturbance in his series emphasized. In only five of the cases was there a manometric block; eight showed radiological evidence of calcification in the affected intervertebral disk. Six cases did well after operation but all had residual signs; three developed post-operative total transverse lesions of the cord and two others were made worse by surgery. No separate account of protrusions of the lumbo-dorsal or first lumbar intervertebral disk with compression of the conus medullaris has been encountered in the literature. A few protrusions at the former level have been included in the recorded series of thoracic protrusions; protrusions between the first two lumbar vertebræ are extremely uncommon when the frequency of protrusions of the last two lumbar disks and the occasional occurrence of protrusions of the second and third lumbar disks

development of a severe and permanent neurological deficit and the frequently unsatisfactory results of surgical treatment. These matters will be reconsidered in the discussion after the present series of cases has been considered. There are fourteen cases of cord compression by intervertebral disk protrusion in the present series: eight cervical, four thoracic, and two lumbar (*Table II*). It should be noted that in one of the cases classified as cervical the protrusion was of the disk between the 7th cervical and 1st thoracic vertebræ. It appeared—in view of its relationship to the cord segments supplying the upper limbs—preferable to regard this as a cervical rather than a dorsal protrusion. Further, of the two classified as lumbar one arose at the interval between the 12th thoracic and 1st lumbar vertebræ and the other at that between the

1st and 2nd lumbar vertebræ. Since in both the protrusion had an intimate relationship with the conus medullaris it seemed correct to classify both as lumbar protrusions. The records of these fourteen cases will first be briefly summarized. Then, in the light of the experience of these cases, the various aspects of cord compression by disk protrusions will be considered in detail.

CASE REPORTS

Case 1.—**A protrusion of disk between 3rd and 4th cervical vertebræ. R. > L.**

A. E., male, aged 53, electrician; admitted May 3, 1940, complaining of weakness of lower limbs.

HISTORY.—Four years before admission he dived into a wave and experienced severe pain at the vertex and paralysis of his limbs. He was dragged ashore and the paralysis had passed in thirty minutes. He walked with a stick for a couple of weeks. A year later he began to experience pain above the left iliac crest after exercise and after another two years a similar pain appeared on the right side. Almost four months before admission subjective coldness of the left foot appeared and the legs became weak with frequent stubbing of the right toes. This was soon followed by stiffness of the medial two fingers of both hands, with numbness of the finger tips and a quivering sensation along the medial margins of the forearms. Shortly before admission he became aware of a grating sensation in his neck on movement and on one occasion a sudden neck movement produced an electric shock sensation throughout his body. For some months there had been weakness of the anal sphincter. There were no symptoms referable to other systems and there was nothing significant in the past or family history.

ON EXAMINATION.—A healthy looking man, and no abnormality was found apart from the evidence of a spinal cord lesion now to be described. There was tenderness over the lower cervical spines and crepitus on neck movement. There was a spastic weakness of the right arm below the deltoid and of both lower limbs, the right more than the left. Cutaneous sensory modalities were unaffected but vibration sensibility was reduced in the right upper and both lower limbs. The tendon reflexes were brisk in all limbs, the abdominal reflexes present and the plantar responses extensor. Romberg's sign was positive and the gait spastic. Laboratory investigation of blood and urine and radiographic examination of the cervical spine showed no abnormality. The results of manometric tests at lumbar puncture were not recorded in this patient's notes but the cerebrospinal fluid protein was 125 mg. per cent, and the Wassermann reaction negative. Myelography revealed no block or any evidence of a filling defect.

On the clinical diagnosis of spinal cord compression at the 5th cervical segment cervical laminectomy (C.3–7 inclusive) was performed. Immediately to the right of the midline a protrusion of the disk between the 3rd and 4th cervical vertebræ was found and excised transdurally. It was composed of calcified fibrocartilage.

This patient was discharged from hospital improved and when last examined eight years post-operatively he was fully employed as an electrician, and complained only of some stiffness of the right shoulder and occasional tingling in fingers. The only abnormal sign was slight weakness of abduction of the right shoulder.

Case 2.—**A protrusion of the disk between 4th and 5th cervical vertebræ. L. > R.**

G. T., male, aged 44, engine driver; admitted July 2, 1942, complaining of aching in shoulders, and tingling in hands and feet.

HISTORY.—Nine months before his admission he developed aching pain in both shoulders followed after two weeks by a sharper pain radiating from the cervical through the dorsal to the lumbar spine which occurred after lifting. Three months after the onset of these symptoms his legs began to feel heavy and his feet began to drag—the right being the more severely affected. There also appeared tingling and weakness of both hands aggravated by neck flexion. Soon there developed tingling and burning in the right leg and aching pain in the left foot and on several occasions following a cough involuntary extension of the left leg occurred causing him to fall. There was no disturbance of sphincter control or symptoms referable to other systems and there was nothing relevant in his past or family history.

ON EXAMINATION.—An incapacitated man showing a cervical scoliosis convex to the left and in whom neck movement caused tingling in both hands; there was no cervical tenderness. General examination revealed no abnormality and the neurological examination was negative apart from the signs of a cervical cord lesion to be described. There was a spastic tetraparesis with poor performance of rapid movements and slight ataxia, the left limbs being more severely affected. There was a hypo-æsthesia, hypo-algesia, and therm-hypæsthesia below the fifth cervical dermatome with some over-reaction to pain and temperature stimuli on the right side. Postural and vibration sense were reduced in all limbs. The biceps and supinator jerks were normal, the triceps, knee, and ankle jerks being exaggerated, the abdominal reflexes present, and the plantar responses extensor. The gait was markedly spastic. Laboratory investigation of the blood and urine showed no abnormality. Radiological examination showed a normal cervical spine and lumbar puncture no evidence of subarachnoid block. The cerebrospinal fluid protein was 50 mg. per 100 ml. and the Wassermann reaction negative. Myelography revealed a filling defect opposite the interval between the 4th and 5th cervical vertebral bodies on the left side.

A clinical diagnosis of compression of the cervical cord at the sixth cervical segment was made and cervical laminectomy (C.3–7 inclusive) performed. The cord was found to be displaced to the right by an anterior extradural mass. Incision of its coverings revealed this to be a protrusion of the disk between the 4th and 5th cervical vertebræ which was excised transdurally. The excised tissue consisted of normal fibrocartilage and weighed 0·8 g.

Following discharge this patient returned to light work. When examined six years post-operatively he still complained of tingling in his right leg and of stiffness in both legs. The only abnormal signs were spasticity and reduction of vibration sense in the lower limbs.

Case 3.—**A protrusion of the disk between 5th and 6th cervical vertebræ. L. > R.**

L. W., male, aged 44, musician; admitted Sept. 15, 1944, complaining of weakness of the left limbs and muscle spasms in the legs.

HISTORY.—Eleven months before admission, while in bed with pneumonia, he developed pain in the left index finger which persisted. Six months later he began to stub the toe of his left shoe in walking and noticed weakness of his left hand. Six weeks before admission he developed recurring involuntary spasmodic movements of his lower limbs and shortly afterwards tingling in his left hand and fingers. There then developed numbness of the body below the neck—including the right hand. There had been some difficulty of micturition. There were no symptoms referable to other systems or anything relevant in his past or family history.

ON EXAMINATION.—An intelligent, anxious man. General examination showed no abnormality apart from dental caries and the abnormalities on neurological investigation were limited to a congenital nystagmus and the signs of a spinal cord lesion now to be described. Cervical movement was full, there being no spinal

tenderness and Naffziger's test was negative. There was a spastic weakness of the left arm, below the muscles supplied by the 6th cervical segment, and of both legs. There was hypoæsthesia below the 2nd thoracic dermatome bilaterally with, on the right, hypo-algesia and therm-hypæsthesia to the same level. Postural and vibration sensibility were not disturbed. The tendon reflexes in the left arm and both legs were hyper-active, there being sustained patellar and ankle clonus. The abdominal reflexes were absent and the left plantar response extensor. He was unable to stand. Laboratory examination of the

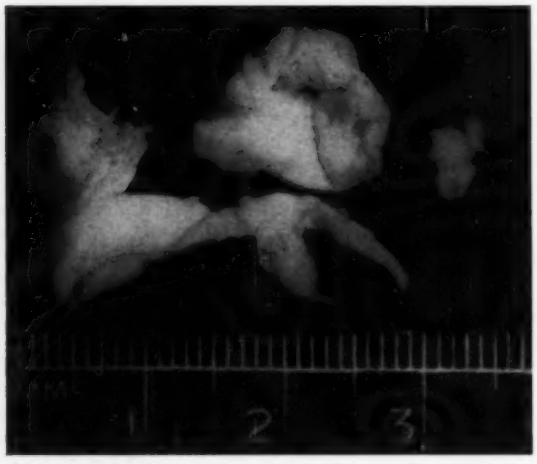


FIG. 275.—Cervical intervertebral disk protrusion, weighing 1 g., excised at operation. (*Case* 4.)

blood and urine showed no abnormality. Radiography revealed narrowing of the intervals between the 4th and 5th and 5th and 6th cervical vertebræ and lumbar puncture a partial subarachnoid block with a protein of 60 mg. per 100 ml. Myelography showed filling defects opposite the intervals between the 4th and 5th and 5th and 6th cervical vertebræ.

A clinical diagnosis of compression of the spinal cord at the 7th cervical segment, greater on the left side, was made and laminectomy (C.4–7 inclusive) performed. A protrusion of the disk between the 5th and 6th cervical vertebræ immediately to the left of the midline was found and removed. The mass was covered by the rootlets of the left 6th cervical nerve which was sectioned to provide adequate exposure.

The patient left hospital improved and when last heard of four years post-operatively he had resumed his occupation as a violinist, though he was handicapped by tingling and weakness of the left hand. He also suffered cramps in his legs.

Case 4.—**A protrusion of the disk between 7th cervical and 1st dorsal vertebræ. R. > L.**

G. R., male, aged 31, sailor; admitted July 6, 1945, complaining of paralysis of legs.

HISTORY.—For ten months before his admission he had had low posterior cervical pain spreading to the right shoulder region. This was more severe at night and interfered with sleeping. Two months before admission, pain along the ulnar side of the right forearm appeared with some associated tingling. Then two weeks before his transfer he was admitted to another hospital having become paraplegic with numbness extending to his axillæ within a period of half an hour. On the following day weakness of the hands had developed and there was retention of urine with fæcal incontinence. There was nothing relevant in the rest of his history.

ON EXAMINATION.—An ill-looking man with tenderness to the right of the 5th cervical spine and slight limitation of neck movement. Naffziger's test was negative. There was a paraplegia and weakness of the muscles of both upper limbs below the elbow flexors—the right being the more severely involved. Tone was not increased and the tendon reflexes were normal, except for a slight reduction of the triceps jerks. The abdominal reflexes and the plantar responses were absent. There was analgesia and anæsthesia below the 7th cervical dermatome with therm-anæsthesia and in addition loss of postural and vibration sensibility in the lower limbs. General examination showed no abnormality, nor did radiography of the cervical spine. On lumbar puncture there was an almost complete subarachnoid block, the cerebrospinal fluid protein being 200 mg. per cent and the Wassermann reaction negative. Myelography showed a filling defect on the right side at the level of the 7th cervical vertebra. Examination of the blood and urine showed no abnormality.

On the diagnosis of compression of the spinal cord at the 7th cervical segment a laminectomy (C.5–T.1 inclusive) was performed. The dural theca and spinal cord were displaced posteriorly and to the left by a very large protrusion of the disk between the 7th cervical and 1st thoracic vertebræ. The mass was excised extradurally, and weighed 1·0 g. (*Fig.* 275). On the second day after operation the patient developed dyspnœa and cyanosis, a right-sided pneumonia and later bilateral pulmonary œdema and died from these complications on the eighth post-operative day. At autopsy a right basal pneumonia was present with a small related empyema. The spinal cord was softened at the level of the compression and showed extensive acute degenerative changes in the dorsal and lateral columns.

Case 5.—**A protrusion of the disk between 5th and 6th cervical vertebræ. R. > L.**

G. C., male, aged 39, agricultural labourer; admitted Aug. 9, 1950, complaining of difficulty in walking.

HISTORY.—Fifteen months before admission he noticed stiffness of the right knee in walking and three months later numbness and tingling in the right leg which spread via the lower abdomen to involve the limb on the opposite side. Six months before admission his left leg became stiff and walking difficult and two months later numbness and tingling appeared in the medial two fingers of both hands—the right more than the left. Micturition became precipitant at this time. He had no pain or other symptoms and there was nothing significant in the past or family history.

ON EXAMINATION.—A healthy looking man who showed no abnormal signs other than those of the lesion of the cervical cord to be described. There was no cervical deformity, tenderness or limitation of movement and Naffziger's sign was negative. There was a spastic tetraparesis—the upper limbs being affected below the muscles supplied by the sixth cervical segment, and the right side being more involved than the left. Cutaneous sensibility was reduced in the lower limbs—the loss extending onto the lower trunk; there was also a reduction of these modalities in the ulnar fingers and ulnar margins of the hands. Postural and vibration sensibility were lost to the level of the iliac crests. The abdominal reflexes were absent and the plantar responses extensor, the knee- and ankle-jerks being exaggerated with sustained clonus. The biceps reflex was normal, the triceps jerk exaggerated, and the supinator jerks inverted. The gait was grossly spastic. Laboratory investigation showed the blood and urine to be normal. Radiography showed narrowing of the interval between the 5th and 6th cervical bodies with sclerosis of the vertebral surfaces adjacent to this interval (*Fig.* 276). Lumbar puncture revealed a partial block on extension of the cervical spine, the cerebrospinal fluid protein being 50 mg. per 100 ml. with a negative Wassermann reaction. Myelography showed an almost complete block at the level of the disk between the 5th and 6th cervical vertebræ (*Fig.* 277).

On the diagnosis of cord compression at the 6th cervical segment laminectomy (C.4–6 inclusive) was carried out (*Fig.* 278). The spinal cord was found to

FIG. 276.—Lateral radiograph of cervical spine demonstrating narrowing of interval between 5th and 6th cervical vertebræ. (*Case* 5.)

be displaced posteriorly and to the left, obliterating the subarachnoid space, by a protrusion of the disk between the 5th and 6th cervical vertebræ. This was excised transdurally. When this had been effected the closure of the posterior dura appeared to carry the risk of compressing the cord and it was therefore left unsutured. The excised tissue weighed 0·7 g.

This patient was discharged improved and when last seen over four years post-operatively he was working as a gardener and could walk several miles easily. His legs were still stiff as was also his right hand. On examination the residual signs were slowness of movement of the right hand and spasticity of the legs.

Case 6.—**A protrusion of the disk between 5th and 6th cervical vertebræ. R. > L.**

W. B., male, aged 46, foreman bricklayer; admitted Jan. 16, 1953, complaining of weakness and tingling in his limbs.

HISTORY.—Three years before his admission he began to have posterior cervical pain radiating first to the right and later to the left shoulder and upper arm. Six months before admission he began to notice a sensation of pins and needles spreading from the shoulders through the trunk to the proximal thighs on coughing and three months later a constant sensation of tingling involved the whole of the right lower limb. Shortly after this his legs became stiff and his gait unsteady. There also developed weakness of the hands, especially the right, and constant tingling in both hands with numbness of the finger tips. He complained of no other symptoms and the only important previous illness was a post-pneumonic empyema for which many operations were required over a thirty year period.

ON EXAMINATION.—A healthy looking man without abnormal signs other than those related to his cervical cord lesion. There was tenderness over the lower cervical spines and extension and rotation of the neck produced paræsthesiæ in the hands. There was a mild weakness of the right arm and of both legs with spasticity. Pain

FIG. 277.—Myelogram showing complete obstruction in the subarachnoid space at the narrow interval between the 5th and 6th cervical vertebræ. (*Case* 5.)

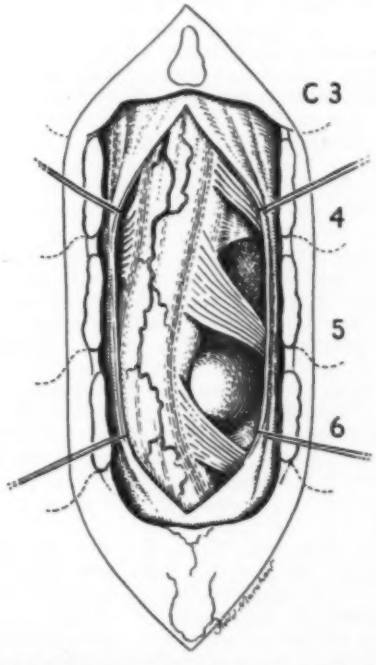


FIG. 278.—Drawing of appearances at operation in *Case* 5. The posterior displacement of the spinal cord with obliteration of the subarachnoid space at the level of the mass is indicated.

and temperature sensibility were reduced below the 5th cervical dermatome bilaterally, and more on the right side. Vibration sensibility was reduced in both legs.

The tendon reflexes were brisk in the arms—particularly the triceps jerks, and also in the lower limbs with extensor plantar responses but the abdominal reflexes were present. The gait was spastic. Laboratory examination of the blood and urine showed no abnormality. Radiography of the cervical spine revealed nothing abnormal and lumbar puncture a partial subarachnoid block with with occasional flexor spasms and a tendency for her legs to give way under her—especially the right leg. There occurred tingling in both hands and the arms felt numb. There were no other symptoms and the past and family histories contained nothing relevant.

On Examination.—A healthy looking woman without abnormal signs other than those of the cervical cord lesion.

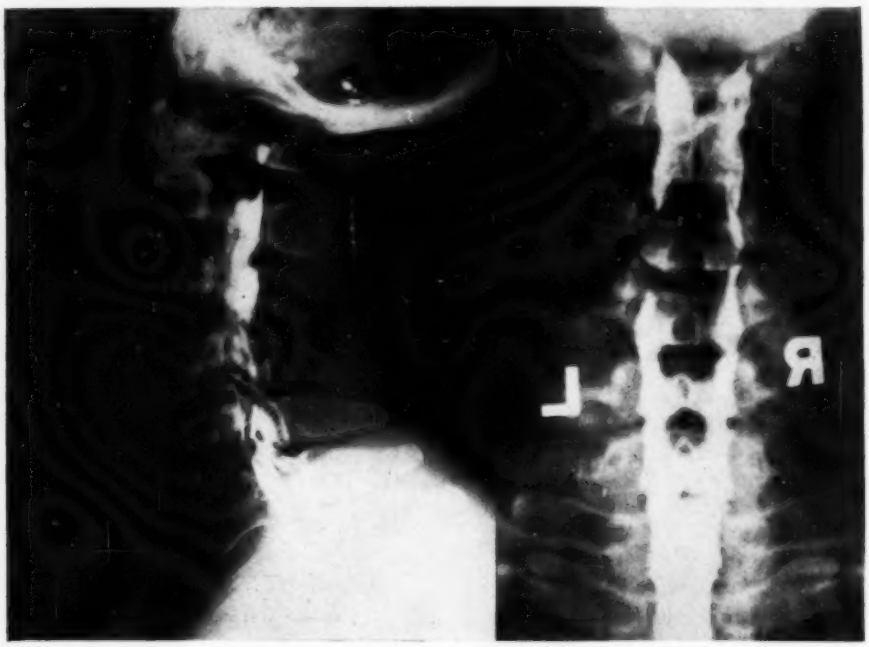


Fig. 279.—Myelograms of *Case* 7. The posterior displacement of the theca opposite the C.4–5 interval is seen in the lateral film while the anteroposterior shows splitting of the column of dye into lateral streams at the affected level.

a cerebrospinal fluid protein of 70 mg. per 100 ml. Myelography revealed a central filling defect at the level of the interval between the 5th and 6th cervical vertebræ.

On the diagnosis of compression of the cord at the 6th cervical segment laminectomy was performed (C.4–6 inclusive). At the interval between the 5th and 6th cervical vertebræ a disk protrusion was found and excised on the left side. On the right side osteo-arthritic lipping was present. Another change which was encountered here was great swelling of the 6th cervical anterior roots on both sides—especially the right where the root formed a rounded mass 5·0 mm. in diameter; biopsy proved this to be œdematous nerve-root only.

The patient was discharged pain free and with less spasticity. When last examined two years after operation he was fully employed as a foreman. Neck movement was free and painless. The lower limbs remained spastic with extensor plantar responses and sensibility remained diminished but less so than pre-operatively.

Case 7.—**Bilateral (R. > L.) protrusion of the disk between 4th and 5th cervical vertebræ.**

G. R., female, aged 38, housewife; admitted Feb. 7, 1955, complaining of weakness of limbs.

History.—For two years before she came to hospital she had suffered from recurring aching pains on the dorsum of each foot and four months before admission she had suffered from a transient stiff neck and pain on the dorsal surface of the right forearm. Shortly after this she noticed weakness of her legs with numbness and tingling while sitting and a cold sensation on standing. At this time following an appendicectomy she developed weakness of grip and increasing weakness of the legs

Movement of the cervical spine was full, there being no tenderness, and Naffziger's sign being negative. There was a tetraparesis with mild spasticity; the weakness of the upper limbs was slight and involved musculature below that innervated from the 5th cervical segment, while in the lower limbs it was more severe and affected the right side more than the left. Appreciation of cutaneous sensory stimuli was slightly reduced below the 7th cervical dermatome, vibration and postural sensibility being unaffected. The tendon reflexes in the upper limbs were normal while in the lower limbs they were exaggerated with sustained ankle clonus, the abdominal reflexes being absent and the plantar responses extensor. Station was normal and the gait spastic. Laboratory examination of the blood and urine showed no abnormality. Radiography showed slight narrowing of the interval between the 4th and 5th cervical vertebræ with minimal posterior lipping. Lumbar puncture revealed a partial subarachnoid block, the cerebrospinal fluid protein being 200 mg. per 100 ml. Myelography showed the dye column split into lateral streams over the bodies of the 4th and 5th cervical vertebræ, with posterior displacement of the theca in the lateral film (*Fig.* 279).

On the basis of a diagnosis of cord compression at the 5th cervical segment laminectomy was performed (C.3–5 inclusive). The cord herniated into the dural incision and dural arachnoid adhesions were present. A large protrusion of the disk between the 4th and 5th cervical vertebræ was present and excised trans-durally through separate incisions on each side of the cord.

This patient was discharged from hospital seven weeks after operation. She then complained of slight cervical pain and stiffness. There was slight weakness of right

finger movement, not sufficient to prevent efficient knitting. The legs remained spastic and gait cautious. Sensory disturbance had disappeared. The biceps jerks were normal, triceps jerks exaggerated, and the radial reflexes inverted. The knee- and ankle-jerks were brisk and the plantar responses flexor.

Case 8.—**Left sided protrusion of the disk between the 5th and 6th cervical vertebræ.**

L. C., male, aged 22, medical student; admitted March 4, 1955, complaining of pain in the neck and weakness of his left limbs.

HISTORY.—Three hours before examination during a game of rugby football he was tackled after passing the ball from a scrum and fell so that his cervical spine was flexed. There was immediate pain in the back of his neck and weakness of his left arm. He continued to play but in the course of a couple of minutes he developed very severe neck pain and fainted. On recovery of consciousness there was evident a severe weakness of his left side. During the period of his journey to hospital and immediately after his admission the severity of his hemiparesis diminished and his cervical pain spread to both shoulders. There was urinary retention.

ON EXAMINATION.—A strongly built young man showing no evidence of shock. There was tenderness over the lower cervical spines and especially immediately to the left of these. There was a well-marked left hemiparesis: in the upper limb the power of abduction of the shoulder and flexion of the elbow was normal, the triceps was grossly weak and flickering contractions of more distal muscles alone occurred; in the lower limb, toe and ankle movement was absent and there was gross weakness of proximal muscles; tone was not affected. There was a right sided hemi-analgesia and thermanæsthesia extending proximally to include the second dorsal dermatome. Touch, and postural sensibility were unaffected but vibration sense was reduced in the lower limbs. The abdominal reflexes were absent, the left plantar response was extensor and the left triceps and supinator jerks reduced. Radiography showed narrowing of the interval between the 5th and 6th cervical vertebræ with a mild degree of compression of the body of the lower of these vertebræ.

The clinical diagnosis of an acute protrusion of the disk between the 5th and 6th cervical vertebræ with concussion and contusion of the cord was made and immobilization in slight extension obtained by means of skull traction (6 lb.). On the following day considerable improvement was evident. In the left leg all movements were possible and apart from gross weakness of finger movements there was a marked improvement in power in the left arm. Both plantar responses were now flexor. Power in the hand further improved over the next twenty-four hours, but approximately sixty hours after his injury following a flexion movement of the neck severe cervical and left subscapular pain occurred and the paresis of his left limbs recurred in severe form. Examination after a further interval of twelve hours showed that although improvement had occurred the power on the left had deteriorated considerably below its level on the day after injury. As a new sensory finding there was hypo-algesia in the 5th and 6th cervical dermatomes on the left and the left plantar response had again become extensor. There shortly occurred another attack of severe cervical and left brachial pain and this was followed by a further deterioration in power and immediate laminectomy was decided upon.

While the skull traction was maintained the patient was turned into the prone position on the operating table and the head rest adjusted so that neck flexion could not occur. After infiltration of the operative field with 0·5 per cent xylocaine and in 1 in 250,000 adrenalin in saline the spines and laminæ of the 4th to the 6th cervical vertebræ inclusive were excised. On the left side of the theca opposite the 6th cervical lamina there was a firm resistance and pressure here caused pain beneath the left scapula. Owing to the sensitivity of dura mater extradural exploration was found impracticable and the theca therefore incised, pieces of lintine soaked in 0·5 per cent xylocaine being placed on the 5th and 6th cervical posterior roots. Retraction of the cord was then possible and it was found that the spinal canal was shallow on the left at this level and after division of a slip of the dentate ligament a large soft extradural mass was revealed. The dura was incised over it and two large free fragments of disk tissue withdrawn. No protrusion was present on the right side of the cord and this structure itself showed no abnormality. After closure of the wound and the application of dressings the patient was returned to bed and the skull traction re-applied. At this time a marked improvement in power was already present. One week post-operatively power in the left leg was normal, and in the left arm there had been an excellent recovery of power, although the intrinsic muscles remained weak as also the wrist flexors. The right sided sensory change persisted but the abdominal reflexes had re-appeared and normal micturition was re-established.

Four weeks post-operatively there had occurred a further improvement in power with a mild weakness of the intrinsic muscles of the left hand as the residual motor deficit. The absence of pain sensibility on the right persisted to the 6th dorsal segment. Extending superiorly from this level to include the second dorsal dermatome was an area of reduced pain sensibility. Temperature sensibility showed a considerable improvement on the right although it remained reduced. The radial reflex on the left was inverted.

Case 9.—**A protrusion of the disk between 2nd and 3rd thoracic vertebræ. L. > R.**

T. S., female, aged 42, housewife; admitted Sept. 22, 1939, complaining of stiffness of back and legs.

HISTORY.—Five months before admission her legs gave way and she fell down several steps. Shortly afterwards her back became stiff as did her legs which were also subjectively cold and heavy. There was precipitancy of micturition and defæcation. The weakness of the legs increased and there developed a gripping sensation around the upper chest. On flexing the neck she would sometimes experience pain down through the spine into her lower limbs. There were no other symptoms and nothing of significance in the past or family history.

ON EXAMINATION.—A healthy looking woman without abnormal signs other than those due to the spinal cord lesion. There was no spinal tenderness, but full flexion and extension of the neck caused pain down the spine into the lower limbs. There was a spastic paraparesis and reduced cutaneous sensibility below the 3rd dorsal dermatome with diminished sense of vibration below this level. The abdominal reflexes were absent, the plantar responses extensor, and the knee- and ankle-jerks exaggerated with sustained clonus at the ankles. The gait was spastic. Examination of the blood and urine showed no abnormality. Lumbar puncture showed no subarachnoid block and the cerebrospinal fluid protein was 50 mg. per 100 ml. A cisternal myelogram suggested a partial obstruction to the flow of the dye at the interval between the 2nd and 3rd thoracic vertebræ.

On the diagnosis of cord compression in the upper dorsal region laminectomy was carried out (D.1–3 inclusive) and a protrusion of the disk between the 2nd and 3rd thoracic vertebræ, larger on the left side, was found and removed.

When discharged six weeks after operation there was considerable symptomatic improvement. The objective sensory disturbance had cleared up but the reflex abnormalities were still present. Attempts to trace this patient for follow-up examination have failed.

Case 10.—**A protrusion of the disk between 9th and 10th thoracic vertebræ. R. > L.**

O. K., female, aged 34, housewife; admitted Sept. 20, 1946, complaining of weakness of legs.

HISTORY.—Twelve months before admission, while five months pregnant, she developed aching in her calves and had several inexplicable falls. Later, following a miscarriage, her legs were noticed to be weak. Five months later she began to suffer from pain in the left lower chest which persisted for several weeks and was aggravated by breathing. Four months before admission pain appeared on each side of the lower dorsal spine, the weakness worsened and numbness of the legs developed, spreading from the right to the left. There was no disturbance of sphincter control or other symptoms. There was nothing relevant in the past or family history.

ON EXAMINATION.—A healthy looking woman without abnormal signs other than those due to her spinal lesion, except for a bilateral deafness of middle ear type. Naffziger's sign was negative but full neck flexion caused low dorsal pain. There was a severe spastic paraparesis, the right side being affected more than the left and Beevor's sign being positive. There was a gross reduction of all cutaneous sensory modalities below the 10th thoracic dermatome, the left side being more affected, while vibration and postural sensibility were absent in the right leg and reduced in the left. The lower abdominal reflexes were absent, the plantar responses extensor and the knee- and ankle-jerks exaggerated with sustained ankle clonus. The gait was spastic. Examination of the blood, including Wassermann reaction, and urine showed no abnormality. Radiography showed a calcified shadow at the level of the 10th dorsal vertebra and calcification of the disk between the 10th and 11th dorsal vertebræ (*Fig.* 280). Lumbar puncture showed an almost complete subarachnoid block and the cerebrospinal fluid protein was 55 mg. per 100 ml.

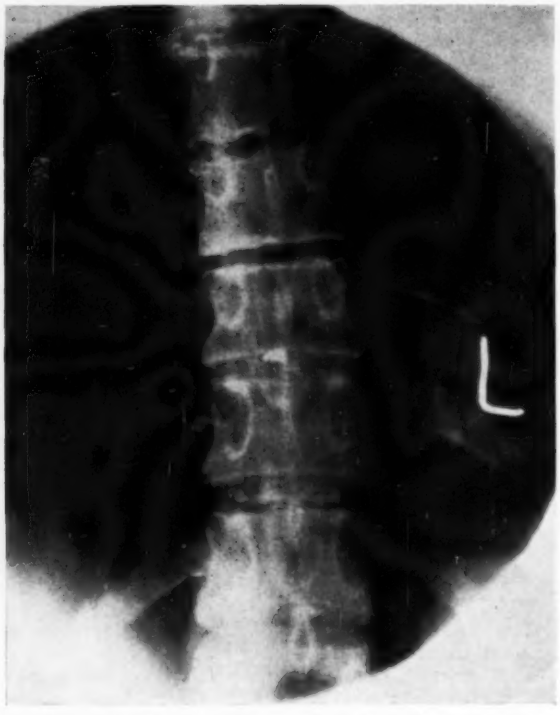


FIG. 280.—Anteroposterior radiographs of lower thoracic spine in *Case* 10. The calcified protrusion at the T.9-10 interval is seen and calcification in the T.10–11 and other intervals revealed.

On the diagnosis of compression of the spinal cord at the level of the 10th thoracic vertebra laminectomy was performed (T.8–11 inclusive). An anterior extradural mass (2 cm. × 1·5 cm.) greatly displacing the cord was displayed and found to be a protrusion of the disk between the 9th and 10th thoracic vertebræ (*Fig.* 281). The dura over its summit was adherent to the pia arachnoid. Extradural incision was effected, both the soft centre and the calcified marginal portions being excised—the mass weighing 0·65 g.

The patient was discharged seven weeks after operation and when last seen her only abnormal signs were exaggerated knee- and ankle-jerks and extensor plantar responses. Six years after operation she was asymptomatic and working in a factory as well as caring for her home.

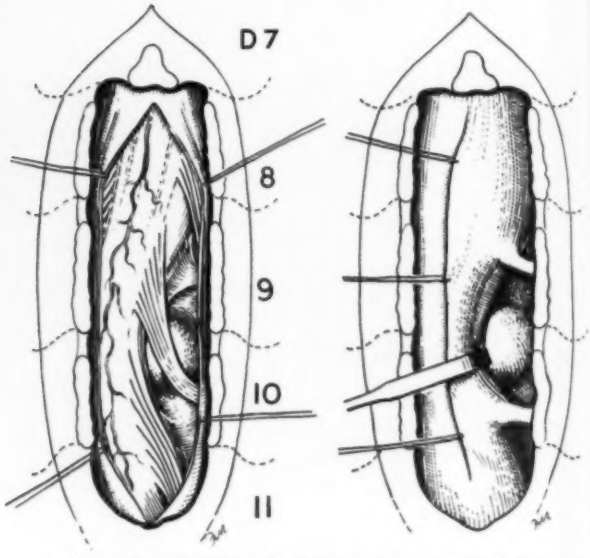


FIG. 281.—Drawing of appearances at operation in *Case* 10. On the left the preliminary intradural exposure of the lesion is represented, and on the right the subsequent extradural exposure preparatory to its excision.

Case 11.—**A protrusion of the disk between 9th and 10th thoracic vertebræ. L. > R.**

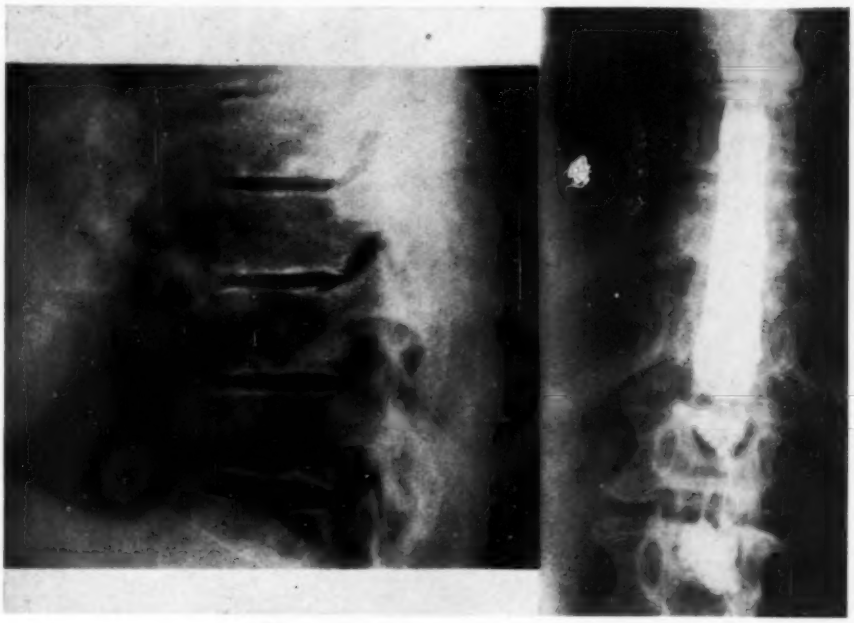
B. K., male, aged 40, taxi driver; admitted April 12, 1947, complaining of weakness of the legs.

HISTORY.—Eighteen months before admission he began to notice unsteadiness of gait and subjective weakness of his legs. He also noticed aching pains in the calves and feet and recurring involuntary extension movements of his legs. Six months later he became aware of a dead sensation in the lower half of his body and coldness and tingling of his feet. After a further three months he developed pain radiating from the lumbo-dorsal region to the right lower abdomen. Precipitant micturition appeared. Two weeks before admission he fell onto his back and was subsequently paraplegic for five minutes. There were no other symptoms or anything relevant in the past or family history.

ON EXAMINATION.—A healthy looking man without abnormal signs other than those related to his spinal lesion. There was no spinal tenderness, deformity, or limitation of movement and Naffziger's sign was negative. There was slight hypertonia in the legs with weakness of toe movement and unsteadiness of the heel-knee test bilaterally. Beevor's sign was negative. There was no definite reduction of cutaneous sensibility, but sense of position and vibration, and graphæsthesia were reduced in the lower limbs. The lower abdominal reflexes were absent, the knee- and ankle-jerks brisk and the plantar

responses extensor. Romberg's sign was positive and the gait spastic and ataxic. Examination of the blood (including Wassermann reaction) and urine showed no abnormality. Radiography of the spine was likewise normal. Lumbar puncture showed a complete subarachnoid block and the cerebrospinal fluid protein was 75 and 120 mg. per 100 ml. on different occasions. Myelography showed a complete obstruction to the flow of the dye at the 10th thoracic vertebra.

—more on the left than the right with hyperæsthesia in the right 10th thoracic dermatome. Vibration sense was absent in the lower limbs and postural sense reduced in the toes. The lower abdominal and cremasteric reflexes were absent, the knee- and ankle-jerks exaggerated and the plantar responses extensor. He dragged his right foot in walking. Examination of the blood and urine showed no abnormality. Radiography showed intervertebral calcification at the 9th–10th thoracic interval



A B

FIG. 282.—On the left, lateral radiograph of lower thoracic spine showing calcification in interval between T.10 and 11. On the right, myelogram in same patient (*Case* 12) showing complete obstruction to the flow of dye at the affected level.

On the diagnosis of cord compression at the above level laminectomy (T.7–10 inclusive) was performed. An anterior extradural mass was found at the level of the disk between the 9th and 10th thoracic vertebræ. While the mass extended across the midline its greatest prominence was left sided. Extradural excision of the hard mass was effected (weight 1·6 g.).

The patient was discharged in four weeks much improved. When last examined five years post-operatively he was fully employed and without abnormal signs.

Case 12.—**A protrusion of the disk between 9th and 10th thoracic vertebræ. R. > L.**

L. R., male, aged 46, fish merchant; admitted May 21, 1954, complaining of difficulty in walking.

HISTORY.—Two years before admission he suffered for six months from aching pain along the inner side of his right ankle. As this subsided he noticed numbness spreading from the right foot upwards to the groin and he began to stub his right toes in walking. A year before admission pain radiating from the right loin to the lower abdomen aggravated by bending and turning developed and occasional incontinence of fæces occurred. Later difficulty of micturition developed and numbness and stiffness of the left leg appeared and walking became increasingly difficult. There were no other symptoms and the past and family histories contained nothing relevant.

ON EXAMINATION.—A healthy looking man and the abnormal signs were confined to those due to his spinal lesion. There was no spinal tenderness, deformity, or limitation of movement. There was weakness of the lower abdominal muscles with a mild spastic paraparesis, the right side being the more affected. Cutaneous sensibility was reduced below the 12th thoracic dermatome (*Fig.* 282 A) and lumbar puncture a partial block with a cerebrospinal fluid protein of 90 mg. per 100 ml. Myelography showed an obstruction to the flow of dye at the level of the disk showing radiological calcification. (*Fig.* 282 B.)

On the diagnosis of cord compression at this level laminectomy (T.8–10 inclusive) was performed and a localized protrusion of the disk between the 9th and 10th thoracic vertebræ embedded in the right antero-lateral column of the cord was found—the cord being displaced posteriorly and to the right. The mass—soft centrally and firm at its periphery—was excised.

The patient was discharged improved in six weeks and when last seen five months post-operatively he was symptom free and showed no abnormal signs, having returned to his occupation three weeks after discharge.

Case 13.—**A protrusion of the disk between 12th thoracic and 1st lumbar vertebræ. L. > R.**

W. B., male, aged 47, engineering turner; admitted Oct. 22, 1948, complaining of pain down the front of his left leg.

HISTORY.—He had had recurring low back pain for twelve years and a severe attack of right anterior crural pain eight years before admission—being incapacitated for four months at that time. Three years before admission he had another attack of crural pain (both anterior and posterior)—left sided on this occasion. This recurred eight months before admission and persisted in severe form, being greatly aggravated by his chronic cough. The pain was felt in the low back, buttock, posterior thigh, anterior thigh, patella, and shin regions of the left side. There was some tingling in the posterior crural part of this area. There was no loss of power

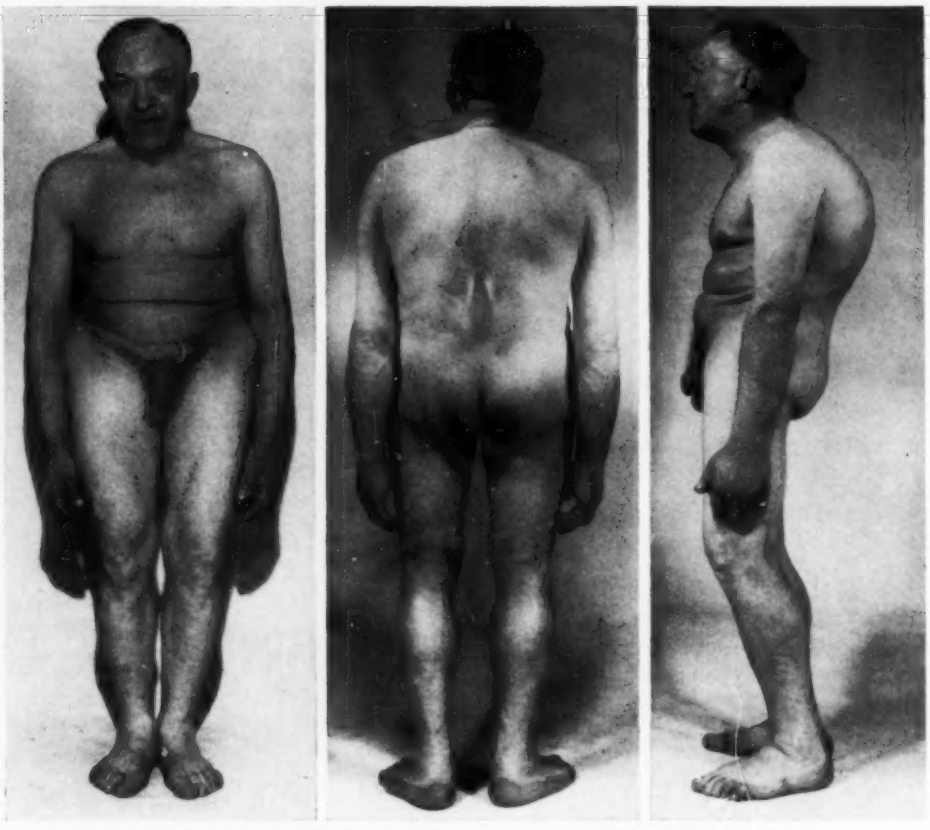


FIG. 283.—Post-operative photograph (*Case* 13) to show acromegalic features.

FIG. 284.—Post-operative lateral radiograph of thoraco-lumbar spine (*Case* 13). Silver clip indicates level of affected interval (T.12–L.1). The increasing anteroposterior measurement of the vertebral bodies from L.1 to T.10 is well shown.

FIG. 285 —Myelogram of *Case* 13. An almost complete obstruction to the upward flow of dye is present on the posterior surface of the first lumbar vertebral body.

but recent difficulty of micturition had developed. The other significant features of his history were the fact that he had severe chronic bronchitis and was acromegalic; apart from this the past and family history contained nothing relevant.

On Examination.—An acromegalic man (*Fig.* 283), dyspnœic, and complaining of very severe pain. There was a lumbar kyphosis with a scoliosis convex to the left and gross limitation of movement; pressure over the 2nd lumbar spine caused pain in the left leg. Naffziger's test was strongly positive as were the straight leg raising and femoral nerve stretch tests—much more so on the left than on the right. There was atrophy and hypotonia of all muscle groups in the left lower limb as well as slight weakness of extension of the right toes. The only sensory change was slight reduction of cutaneous sensibility in the right 4th lumbar dermatome. The left knee-jerk was reduced. General examination showed the features of acromegaly and also evidence of well marked chronic bronchitis and emphysema. Examination of the blood and urine showed no abnormality. Radiography showed the changes of acromegaly and some rarefaction of the skeleton (*Fig.* 284). Lumbar puncture demonstrated a complete subarachnoid block and a cerebrospinal fluid protein of 160 mg. per 100 ml. Myelography showed an obstruction to the flow of dye at the interval between the 12th thoracic and 1st lumbar vertebral bodies (*Fig.* 285).

On the diagnosis of compression of the cauda equina and conus medullaris laminectomy (T.12–L.2 inclusive) was performed. A disk protrusion in close contact with the left side of the conus was found—the injected dura covering the mass being adherent to the pial covering of that structure. Extradural excision of a mass weighing 3·5 g. was effected.

Post-operatively his pain was greatly benefited. When last seen four years after operation his condition was much improved but he was subject to occasional low back pain sometimes radiating to the left leg. He was employed as a store-keeper and spinal movement was full, there being but slight reduction in straight leg raising and femoral nerve stretching. The neurological signs were unchanged.

Case 14.—**A protrusion of the disk between 1st and 2nd lumbar vertebræ. R. > L.**

C. W., male, aged 40, wood merchant; admitted July 11, 1951, complaining of paralysis of right leg.

History.—For nine years he had had recurring attacks of low back and lower limb pain, the latter being bilateral posterior and left anterior crural in distribution. Ten days before his admission such an attack developed—the pain being equally severe in the two legs. He noticed tingling and numbness in his right calf followed after three days by weakness of the right leg which rapidly developed into a paralysis of the limb. In addition there was transient retention of urine with subsequent incontinence of both urine and fæces. The outstanding feature of his past history was the development of acromegalic giantism which left him in a hypopituitary state at the age of 21.

On Examination.—An acromegalic giant (*see Fig.* 287) who was unable to stand because of the paralysis of his right leg. There was tenderness to the left of the 2nd lumbar spine and the straight leg raising and femoral nerve stretch tests were positive on the right. There was an atonic paralysis of the right leg with flexion and adduction of the hip as the only movements possible and these grossly weak. There was slight hypotonia of the left lower limb. There was reduced sensibility from the 2nd lumbar dermatome distally on both sides—greater on the right. All the reflexes were absent in the right leg. The left knee-jerk was weakly obtained and the plantar response flexor. General examination showed no abnormality other than that due to the endocrine disturbance and examination of the blood and urine revealed nothing abnormal. Radiography revealed the spinal changes of acromegaly and gross osteo-arthritic change. Lumbar puncture showed a partial sub-arachnoid block and the cerebrospinal fluid protein was 200 mg. per 100 ml. Myelography produced inconclusive evidence owing to the subdural injection of much of the

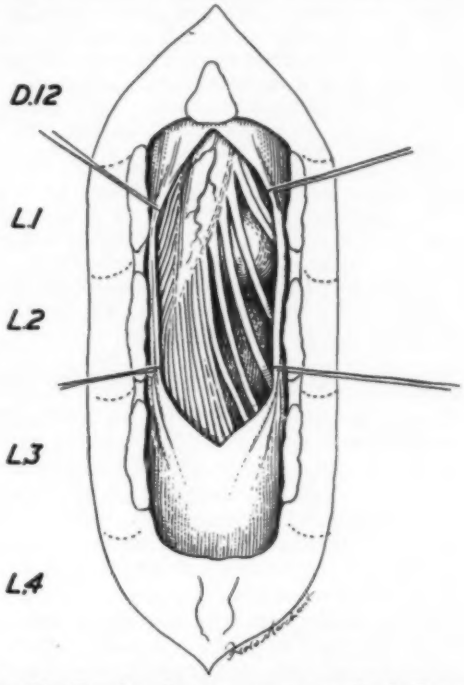


Fig. 286.—Drawing of appearances at operation in *Case* 14. The intimate relationship between the mass and the conus medullaris, which is displaced posteriorly and to the left, is indicated.

Fig. 287.—Post-operative photograph of *Case* 14—an acromegalic giant of 7 ft. standing beside a man of 5 ft. 8 in.

dye; it was possible that there was a right-sided filling defect at the level of the 2nd lumbar body.

On the basis of a diagnosis of compression of the conus medullaris and cauda equina, laminectomy (L.1–3 inclusive) was performed and a large median protrusion of the disk between the 1st and 2nd lumbar vertebræ displacing the conus and cord to the left was found (*Fig.* 286). A transdural excision was effected on both sides of the conus, the weight of the tissue excised being 2·3 g. The prominent osteo-arthritic lips related to the protrusion were not excised. (*Fig.* 287.)

When discharged three months after operation this patient was pain free and power in the right leg was markedly improved. When examined three and a half years after operation he was able to walk short distances without a stick. He was occasionally incontinent of urine, especially at night. There was good power in the right leg apart from inversion, eversion, and dorsiflexion of the ankle which were grossly weak; there was still sensory reduction, less in degree, in the right leg and the reflex abnormality was unchanged. He was able to do a little work in the family business.

ANALYSIS OF CASE RECORDS

Age.—The eight cervical protrusions occurred in patients between the ages, of 22 and 53 the average age being 40 years (*Table II*). The ages of the four patients with dorsal protrusions ranged from 34 to 46, the average age being 40 years. The two patients with lumbar protrusions were aged 40 and 47. Thus the patients in this series with an average age of 40 years were middle-aged and should not be regarded as having entered the degenerative period of life.

Sex.—Seven of the patients with cervical protrusions were men and one a woman. The four dorsal protrusions were equally divided between the sexes and both the lumbar protrusions occurred in men. Thus in the whole series eleven of the patients were male and three female.

Aetiology.—Although several of the male patients were engaged in occupations which involved physical stress, in only two, both with cervical protrusions, did a definite injury appear to be of aetiological importance. One of these (*Case* 1) had, four years before his admission to hospital, dived into a wave and developed an immediate tetraplegia; within thirty minutes the paralysis had passed but he walked with a stick for a couple of weeks after the incident. He remained well, apart from some bilateral loin pain, for over three years when cord function again became impaired and later a protrusion of the disk between the 3rd and 4th cervical vertebræ was excised. The second (*Case* 8) developed evidence of a lesion of the left anterolateral column of the spinal cord at the 6th cervical segment following a flexion injury of the neck. The neurological signs diminished over two days of cervical immobilization in traction but then recurred severely and a large protrusion of the disk between the 5th and 6th cervical vertebræ was found and removed. In spite of the absence of a history of injury in the other cases it seems probable that trauma, in the widest sense of the term, was an aetiological factor in some of them—especially in the mobile cervical and lumbar segments of the spinal column. It would seem likely that strains, the result of postural stresses, which would be of little significance in other ligaments might, in the case of those which contain the nucleus pulposus permit of the extrusion of disk tissue.

One of the female patients developed symptoms of a dorsal disk protrusion during the seventh month of pregnancy. This may be more than coincidence since it has previously been pointed out (O'Connell, 1951) that 17 per cent of a group of 170 female patients with proven lumbar disk protrusions developed these during pregnancy. Postural stress, and muscular contractions during labour, may be factors of importance here and it has further been suggested (O'Connell, 1944) that the corpus luteum hormone thought to be responsible for the increased mobility of the pelvic joints in pregnancy may have a similar effect upon certain other joints.

Both the patients who developed protrusions at the level of the conus medullaris were acromegalics, one being a giant (*Figs.* 283, 287). It has been shown by Erdheim (Albright and Reifenstein, 1948) that in acromegaly bone formation occurs in the cartilagenous end plates of the vertebræ and this together with subperiosteal osteogenesis gives rise to an increase in the width of the vertebral bodies especially in an anteroposterior direction—the change being maximal at the level of the 9th dorsal vertebra and being clearly visible radiologically. This increase in anteroposterior measurement of the lower dorsal and upper lumbar vertebral bodies was present in both the patients in this series and is well seen in *Fig.* 284. The extent of the change can be indicated by comparing on the radiographs the anteroposterior dimensions of the bodies of a succession of vertebræ in normal and acromegalic spines. Each vertebra is measured at its superior and inferior surfaces and midway between these and the average of the measurements taken. In a normal control the measurements were: 3rd lumbar vertebra 4·5 cm.; 2nd 4·8 cm.; 1st 4·7 cm.; 12th thoracic vertebra 4·7 cm. In the spine of *Case* 13 the measurements were 3rd lumbar vertebra 4·9 cm.; 2nd 5·2 cm.; 1st 6·2 cm.; 12th dorsal vertebra 7·2 cm. It is accepted that the overgrowth of bone in acromegaly results from the stimulus of the growth hormone. However, the fact that in the spine the new bone formation described is limited to the lower thoracic and upper lumbar segments and is not generalized indicates that this overgrowth is also dependent upon other factors. Among the latter local stresses may be as important as they are in the development of bone in early life. Thus the massive overgrowth of the anterior portions of these vertebral bodies may serve to buttress the kyphotic acromegalic spine at a point of major stress. If this be in fact the case then it would be justifiable to assume that the same stress was responsible for the development of the intervertebral disk protrusions in the two patients now under consideration. Moreover, it seems likely that the increase in the area of the vertebral surfaces adjacent to an intervertebral disk will weaken the normal attachment of that structure to the vertebræ, even though overgrowth of the intervertebral disks in the affected segment of the spine is said to occur.

Another possible aetiological factor which merits consideration is degenerative changes in the intervertebral joints. The frequency of radiologically demonstrable calcification in the lower thoracic intervertebral disks in the case of protrusions at this

level has been mentioned by a number of authors and the protrusion itself has been found at operation to be calcified in a proportion of the recorded cases. In the present series two of the three patients with protrusion of the disk between the 9th and 10th thoracic vertebræ showed radiological calcification in one or more of the lower thoracic intervertebral disks and in each of the three the tissue removed at operation showed calcification or ossification. Further, in one of these patients (*Case* 12), the material in the centre of the mass was semi-fluid and at first thought to be pus in a chronic abscess. It is likely that these degenerative changes, so commonly encountered in the lower thoracic intervertebral disks when protrusion of one of them has occurred, do in fact predispose these disks to protrude. The presence of calcification suggests the prior existence of degenerative changes in the disk and the ligaments which contain it—changes which might in themselves render these structures less resistant to stress. Further the disintegrated and fluid disk material lacking the structure and attachments of a normal intervertebral disk, will readily be squeezed through a minor defect in the ligaments which surround it.

At other levels in the spinal column degenerative changes may also have an aetiological relationship with intervertebral disk protrusions. It is usually considered that localized osteo-arthritic changes confined to the joint at which a protrusion has occurred are the results and not the cause of the protrusion, being due to abnormal stresses developed in the joint after the loss of a considerable mass of disk tissue. However, when, in the presence of widespread spondylosis, a large protrusion develops at one of the affected joints it seems probable that this relationship is reversed and the degenerative changes in ligaments render the joint more susceptible to injury and permit the protrusion to occur. It must be stressed, however, that this paper is concerned with cases of true intervertebral disk protrusion and not with diffuse spondylosis. In the latter condition disk protrusions occur only occasionally and then usually as but a minor part of the pathological picture, the intraspinal lesion being composed largely of osteo-arthritic spurs.

On the basis of these observations it is considered that trauma (in the widest sense of the term), hormonal influences, and localized degenerative changes in the spine are the factors which led to the development of intervertebral disk protrusions in this group of patients.

Duration of Illness.—The total pre-operative duration of symptoms in the patients with cervical protrusions varied from 3 days to 4 years—the average being 13 months (*Table II*). During much of this period the symptoms were of cervical and radicular pain and the duration of symptoms pointing to definite spinal cord involvement was considerably shorter, varying from 3 days to 15 months and averaging 4·5 months. In the patients with thoracic protrusions the duration of symptoms varied from 5 to 24 months—averaging 15 months—in every case symptoms of cord involvement having been present throughout. Each of the two patients with compression of the cornus medullaris had had recurring spinal and root pain for periods of 12 to 9 years respectively. The symptom leading to admission to hospital and operation had lasted for 8 months in one case and 10 days in the other. This history of spinal and crural pain recurring for years before the onset of cord symptoms is clearly highly suggestive of an intervertebral disk protrusion. The long duration of symptoms of cord compression in the presence of thoracic protrusions is in contrast with their short duration in cases of cervical protrusions. The relative immobility of the thoracic spine as compared with the cervical may protect the spinal cord from injury by the protrusion and permit of the slow development of cord compression such as occurs with neoplasms. In the presence of a cervical protrusion, however, mobility results in the early addition of trauma to compression and the evidence of spinal cord involvement progresses more rapidly. The frequency of spinal pain in cervical protrusions may likewise be due to the mobility of this spinal segment and the incidence of root pain to the large cervical posterior nerve-roots serving the upper limb and their intimate relationship with intervertebral disks and the anterior wall of the spinal canal.

Symptomatology.—Pain occurring in these cases may, as in the case of spinal tumours in general, involve either the affected segment of the vertebral column—spinal pain, the distribution of posterior nerve-roots adjacent to the lesion—root pain, or be experienced in more distant parts where it would appear to be due to the involvement of sensory pathways in the spinal cord and may be called tract pain. Spinal pain occurred in five of the eight patients with cervical protrusions and in both of those with lumbar protrusions (*Table II*). It was seen in only one of the four patients with dorsal protrusions, however, and an explanation for this has already been suggested. When spinal pain did occur it was an early symptom. It probably arises in the pain sensitive posterior common ligament and annulus fibrosus and also in the diarthrodial joints between the articular processes at the affected level and in the related segments of the paravertebral muscles.

Root pain was more frequent occurring in six of the patients with cervical protrusions and in all the cases with dorsal and lumbar protrusions. In the case of the cervical and lumbar disk protrusions in which it occurred root pain was an early and prominent symptom. While the four patients with dorsal protrusions all developed root pain this appeared later in the chronology—a year or more after the onset of the illness in two patients. Perhaps the smaller size of the thoracic roots and the relatively posterior position of the thoracic nerves as they leave the spinal canal accounts for the late appearance of pain in their distribution and also for the fact that few proven cases of laterally placed thoracic disk protrusions with radicular pain as their sole clinical feature have been recorded.

Pain in areas of the body below those supplied by the cord segments at the level of a compressing lesion may be due to the compression of tracts in the cord by the lesion. The alternative possibilities exist that such pain is due to ligamentous strain secondary to muscular weakness, to spasticity, or to some cause unrelated to the spinal cord compression. Three of the patients with cervical protrusions and three of those with thoracic protrusions experienced pains which may have resulted from tract involvement;

lower limb pain in the patients with protrusions involving the conus must clearly be regarded as being of root origin. Of the three patients with cervical protrusions and possible tract pain, in *Case* 1 a pain occurred above the left iliac crest for three years before other symptoms and was later followed by similar pain on the right. Another patient (*Case* 2) complained of an aching pain in the leg on the side of the protrusion—the symptom appearing after weakness. The third case of cervical protrusion with tract pain (*Case* 7) had experienced recurring pains on the dorsal surfaces of her feet—sometimes left- and sometimes right-sided—for two years before admission and for one year pain in the calves. Three of the patients with thoracic disk protrusions suffered tract pain. One of these (*Case* 12) with a protrusion embedded in the right anterolateral column of the 12th dorsal segment of the cord developed aching pain on the medial aspect of his right ankle as his first symptom. A second (*Case* 11) whose protrusion was at the same level but left-sided had aching in his calves and feet among his earliest complaints and a third patient (*Case* 10) with aching pain in the calves as her first symptom had a right-sided protrusion again involving the 12th dorsal segment. (While in the latter two patients there exists the possibility of the lower limb pain being unrelated to the cord compression, in both of them it developed as the earliest symptom and it would therefore seem possible that it was in fact of tract origin.) It is believed that in two of these patients (*Cases* 2 and 12) the pain was undoubtedly of tract origin. The fact that in both of them it appeared in the lower limb on the side of the protrusion is of interest. Gordon Holmes (1919) in discussing tract pain following spinal injuries noted that it occurred on the side of the cord injury in cases exhibiting a Brown-Séquard syndrome—and not on the opposite side which showed a more or less persistent loss of pain and thermal sensibility. There was in his cases alteration in these modalities of sensation on the side of the pain, however, and this he took to mean a lesion of the ventrolateral column of the side of the spinal cord opposite to that most severely injured. He believed that this lesion was the cause of the spontaneous pain and wondered if the posterior column involvement on the side of the major cord injury was not contributory. Since section of the spinothalamic tract in the conscious patient is not associated with pain it would appear that the tract pain under discussion is a central phenomenon resulting from an alteration in the inflow of sensory stimuli from the affected area. The character of the pain and the associated numbness, coldness, and tingling may have a like significance and recall the sensations of post-herpetic neuralgia.

Motor disturbance was complained of by all the patients. Of those with cervical protrusions one (*Case* 4) had rapidly developed a tetraplegia and another (*Case* 8) a severe hemiparesis. In each of the other six a tetraparesis appeared—except for two in whom the upper limb on the side opposite to the protrusion was spared. In all except one (*Case* 8) the weakness appeared first in the lower limbs and in all the motor defect was greater on the side of the protrusion. Three of the patients were unable to walk on admission and another had recovered from a transient tetraplegia. Two complained of subjective stiffness of the lower limbs and two of tonic spasms—extensor in one and flexor in the other. All the patients with dorsal protrusions complained of increasing weakness of the legs and in two the symptom was at first predominantly unilateral. Two complained of giving way of the legs with falling and two of subjective stiffness of the legs and another of extensor spasms. One of these patients fell onto his back and developed an immediate but transient paraplegia. Of the two patients with lumbar protrusions one developed a sudden paralysis of one leg and the other had but slight subjective weakness of one limb. In the lumbar protrusions motor disturbance was of late onset; in the dorsal protrusions it was the outstanding symptom and appeared early. While in the cases with cervical protrusions it was again an outstanding symptom it was, however, preceded by pain in six of the eight cases.

Subjective sensory disturbance, other than pain, appeared in all patients except one (*Case* 8) in whom the acute onset, severe pain, and the motor deficit were likely to overshadow minor symptoms. In four of the cases of cervical disk protrusion this appeared first in the lower extremities—in one as a coldness of a foot, in another as tingling in one leg, and in two as numbness and tingling of both legs. In these four patients numbness and tingling in the hands and fingers appeared subsequently. The other three patients developed tingling and numbness in one or both upper limbs before any more distal paræsthesiæ arose. In five patients the paræsthesiæ were at first unilateral; when proximal (2 cases) they then affected the limb on the side of the protrusion; where distal in two cases they involved the limb on the side opposite the protrusion and in one that of the same side (*Table II*). All of the patients with dorsal protrusions had subjective sensory disturbances. Three complained of numbness—one with coldness and tingling in addition—and the fourth complained of coldness and heaviness of his legs. One of the patients with a lumbar protrusion developed widespread numbness of a leg at the same time as a monoplegia and the other tingling in the posterior aspect of one limb—both on the side of the protrusion.

Under the heading of subjective sensory disturbance reference should be made to three patients, all with cervical protrusions (*Cases* 1, 2, and 6), who developed electric shock sensations on neck flexion (Lhermittes symptom) or on coughing. In *Case* 1 a sudden neck movement produced an electric shock sensation throughout his body below the neck; *Case* 2 noticed tingling in both hands on neck flexion; and *Case* 6 noticed a similar sensation radiating from the neck through his trunk to the upper thighs on coughing. This symptom was first described in association with wounds of the head and neck and later in cases of disseminated sclerosis and subacute combined degeneration of the cord (Marie and Chatelin (1917), Babinski and Dubois (1918), Reider (1946)). It has also been reported occasionally in cases of tumours of the cervical cord. Since in all these conditions demyelination of nerve-fibres in the cord may be present Lhermitte believed that stimulation of these fibres by neck flexion gave rise to the sensation which he compared to Tinel's sign

in peripheral nerve injuries. During flexion of the neck the spinal cord is drawn both superiorly in the spinal canal and anteriorly against the posterior surfaces of the vertebral bodies and the intervening disks (O'Connell, 1946). The stimulation occasioned by such a movement will clearly be increased in the presence of a space occupying lesion anterior to the spinal cord and this may account for the rather frequent occurrence of the electric shock symptom in cases of cervical disk protrusion. In this connexion it is noteworthy that one of the patients with a dorsal protrusion had symptoms which appear to be related to that described by Lhermitte; *Case* 9 had noticed pain spreading from the spine into the lower limbs on neck flexion.

Disturbance of sphincter control occurred in eleven of the fourteen cases (*Table II*). Of the cervical protrusions two had retention of urine, one with fæcal incontinence in addition, another had occasional fæcal incontinence; one had difficulty of micturition and two others precipitancy. Three of the dorsal protrusions complained of sphincter disturbance; one had precipitant micturition and defæcation; another increased frequency and urgency of micturition, and the third occasional fæcal incontinence and difficulty of micturition. One of the patients with a lumbar protrusion had retention of urine and fæcal incontinence and the other slight difficulty of micturition.

On Examination.—

1. *The Spine.*—No spinal abnormality was detected in the patients with dorsal protrusions. Of the patients with cervical protrusions one (*Case* 8) who had sustained an acute injury of the cervical spine had tenderness over the lower cervical spines and to the left of them; no attempt was made to test cervical movement, the neck being immobilized at the earliest possible opportunity. In the remaining seven patients with cervical protrusions limitation of neck movement was present in three, the movement causing crepitus in one and tingling in the hands in another. In two patients there was tenderness at the level of and on the same side as the protrusion. One patient had developed a lateral tilt convex to the side of the lesion. Both of the patients with lumbar protrusions showed the characteristic deformity of acromegaly. One showed also the signs typical of a lumbar disk protrusion in severe form (lumbar kyphosis with scoliosis and greatly restricted movement); the other was unable to stand before operation, so that a full examination of the spine was not possible.

2. *Tests Designed to Stimulate Mechanically the Posterior Nerve-roots Involved by the Spinal Lesion.*—These were negative in the cases of cervical and dorsal disk protrusions but the two patients with lumbar protrusions had a positive Naffziger's test and the straight leg raising and femoral nerve stretch tests were also strongly positive.

3. *Motor Disturbance.*—Of the cases with cervical disk protrusions the patient with the most severe motor disability (*Case* 4) exhibited a paraplegia without spasticity; in addition there was a paresis of the muscles of both upper limbs below those supplied by the 6th cervical segment with paralysis of finger movement on the side of his lesion. *Case* 8 had a severe hemiparesis on the side of the protrusion; it diminished in severity for two days after his injury and then in association with two attacks of cervical and left subscapular pain power deteriorated almost to the level of a hemiplegia. Of the remaining six cases of cervical disk protrusion four showed a tetraparesis, and two a paresis of both lower limbs and of the upper limb on the side of the protrusion. Each of the four patients with dorsal disk protrusions exhibited a spastic paraparesis. One of the patients with a lumbar protrusion had a paralysis of the lower limb on the side of his protrusion with hypotonia on the opposite side. The other patient had a hypotonia and atrophy of mild degree in the lower limb on the side of the protrusion with slight muscle weakness and in addition weakness of toe extension on the opposite side.

4. *Sensory Disturbance.*—Of the patients with cervical disk protrusions one, *Case* 4, the most severe cord lesion, had analgesia and therm-anæsthesia below the 7th cervical dermatome; sense of position and vibration was absent in the lower limbs and the medial fingers of the right hand. *Case* 8 (C.5–6 protrusion) exhibited analgesia and therm-anæsthesia below the 2nd dorsal dermatome on the side opposite to his hemiparesis. There was also a fluctuating hypo-algesia in the 5th and 6th cervical dermatomes on the side of his weakness. Postural sense was not affected though vibration was appreciated less well below the upper limbs. Four patients, *Case* 2 (C.4–5 protrusion), *Case* 7 (C.4–5 protrusion), *Case* 5 (C.5–6 protrusion) and *Case* 6 (a protrusion of C.5–6 disk) exhibited a reduction of cutaneous and deep sensibility to the appropriate segmental level. The seventh, *Case* 3 (C.5–6 protrusion), showed hypo-algesia, therm-hypoæsthesia, and hypoæsthesia, without involvement of posterior column sensibility, to a level (D.3) several segments short of that involved by the protrusion. The remaining patient, *Case* 1 (C.3–4 protrusion), showed a reduction of posterior column sensibility in the lower limbs, trunk and right arm to the appropriate level but no cutaneous sensory disturbance apart from the distribution of the 5th and 6th cervical roots on the side of the protrusion. Of the patients with dorsal protrusions all showed a reduction of both superficial and deep sensibility below a level corresponding to the affected segment of the spinal cord. In one there was an area of hyperæsthesia in the distribution of the posterior nerve-root related to the protrusion (RT, T.10) and in two the reduction of pain and temperature sensibility was more marked on the side opposite to the protrusion. Of the patients with lumbar protrusions one showed a reduction of cutaneous sensibility, below the 2nd lumbar dermatome—much more marked on the side of the protrusion where postural sensibility and vibration were absent. The other patient showed only a reduction of sensibility in one dermatome (L.4) on the side of his protrusion.

5. *Reflex Disturbance.*—Among the cases with cervical disk protrusions *Case* 4 (C.7–D.1 protrusion) showed normal biceps and supinator jerks with reduced triceps jerks; the abdominal reflexes were absent and no deep or superficial reflexes were obtained in the lower limbs. *Case* 2 (C.4–5 protrusion) showed normal biceps and supinator jerks with brisk triceps jerks; his knee- and ankle-jerks were

brisk with ankle clonus, the plantar responses extensor and the abdominal reflexes present. Three of these cases, *Case* 1 (C.3–4), *Case* 5 (C.5–6) and *Case* 6 (C.5–6), showed a general increase in the deep reflexes—with inversion of the radial reflex in one—ankle clonus, the abdominal reflexes present in two, absent in one and a bilateral extensor plantar response. In one patient, *Case* 3 (C.5–6), there was hyper-reflexia in the arm on the side of the protrusion and in both legs, the abdominal reflexes being absent and the plantar response extensor on the side of the protrusion. Another patient, *Case* 8 (C.5–6), showed absence of abdominal reflexes, an extensor plantar response on the side of the protrusion, with an increased triceps and inverted supinator jerk on the same side. The remaining patient, *Case* 7 (C.4–5), showed no abnormality of the upper limb reflexes, with absent abdominal reflexes, extensor plantar responses, and increased quadriceps and Achilles reflexes and sustained ankle clonus.

All the patients with dorsal disk protrusions showed extensor plantar responses, three of them having hyper-active knee- and ankle-jerks with clonus; in one patient all the abdominal reflexes were absent and in another the lower abdominals only. One of the patients with a lumbar protrusion showed a unilateral reduction of patellar jerk, while the other showed an absence of deep and superficial reflexes in the limb on the side of the protrusion with an absent ankle-jerk on the opposite side.

6. STATION AND GAIT.—Excluding the patients with a tetraplegia (*Case* 4) and the acute injury of the cervical spine (*Case* 8), the other patients with cervical disk protrusions showed a spastic gait and one a positive Romberg sign. The four patients with dorsal disk protrusions likewise had a spastic gait, the limb on the side of the protrusion being more affected. One of the patients with a lumbar disk protrusion was unable to stand as a result of his paralysed lower extremity, and the other was unable to walk because of pain and a period of immobilization in bed.

Accessory Methods of Investigation.—

1. *Radiological Examination of the Spine.*—In 3 of the 8 cervical cases plain films of the spine revealed no abnormality (*Table III*); in the other 5 a narrowing, varying in degree, of the intervertebral interval at the affected level was seen—two adjacent intervals being so narrowed in one case. One patient (*Case* 8) showed a compression fracture of the vertebral body below the narrowed interval. Two of the patients with dorsal protrusions showed no radiological evidence of this. Two showed calcification of an intervertebral disk, in one the disk between the 9th and 10th and in the other that between the 10th and 11th dorsal vertebræ—the former level being the site of the protrusion in both cases. In one of these a calcified intraspinal shadow revealed the site of the protrusion. Both the patients with lumbar protrusions exhibited the radiological changes in the dorsolumbar spine which are characteristic of acromegaly. Narrowing of the affected intervertebral interval was evident in both cases and in one there was widespread evidence of spondylosis.

2. *Cerebrospinal Fluid Dynamics and Protein.*—Of the 8 patients with cervical disk protrusions one (*Case* 8) was not submitted to lumbar puncture

Table III.—RESULTS OF ACCESSORY METHODS OF INVESTIGATION

CASE NO.	LEVEL OF PROTRUSION	RADIOGRAPHY	SUBARACHNOID BLOCK	C.S.F. PROTEIN	MYELOGRAPHY
				Mg. per cent	
1	C.3–4	Normal	—	125	Normal
2	C.4–5	Normal	Absent	50	Defect C.4–5 L.
3	C.5–6	C.4–5, C.5–6 narrow	Partial	60	Defect C.4–5, C.5–6
4	C.7–T.1	Normal	Almost complete	200	Defect C.7–T.1 R.
5	C.5–6	C.5–6 narrow	Partial on neck extension	50	Block C.5–6
6	C.5–6	C.5–6 narrow	Partial	70	Block C.5–6
7	C.4–5 R. > L.	C.4–5 slightly narrow	Partial	200	Defect C.4–5
8	C.5–6 L.	C.5–6 narrow. Compression C.6	— —	— —	— —
9	T.2–3	Normal	Absent	50	Defect T.2–3 L.
10	T.9–10	Calcified mass. Calcified T.10–11	Partial	55	Not done
11	T.9–10	Normal	Complete	75, 120	Block T.9–10
12	T.9–10	T.9–10 narrow. Calcified T.9–10	Partial	90	Block T.9–10
13	T.12–L.1.	Acromegaly. T.12–L.1. narrow	Complete	160	Block T.12–L.1
14	L.1–2	Acromegaly. Gross osteo-arthritic change	Partial	200	? defect L.1–2 R.

and one (*Case* 2) showed no interference with cerebrospinal fluid dynamics. Of the remaining 6 one had an almost complete subarachnoid block. Four had evidence of a partial subarachnoid block and in another, although the results of the manometric tests were not recorded, the cerebrospinal fluid protein level was 125 mg. per cent so that it may be assumed that here too there was a partial subarachnoid block. The cerebrospinal fluid protein level in these 7 cases ranged from 50 mg. to 200 mg. per cent—averaging a little over 100 mg. per 100 ml. (*Table III*).

One of the patients with a dorsal protrusion exhibited a complete subarachnoid block, the protein level being 75 mg. and 120 mg. per cent on different occasions. Two of the others showed a partial block and one normal hydrodynamics, and the protein value in the first 2 being 55 mg. and 90 mg. per cent and in the latter case 50 mg. per cent.

Both the patients with lumbar protrusions had a complete subarachnoid block with protein levels of 160 mg. and 200 mg. per cent respectively.

3. *Myelography.*—This was carried out in 12 cases, being omitted in *Case* 8 because of the recent spinal injury with fracture and *Case* 10 because the calcified protrusion was visible on the plain films. Non-viscous neohydriol was instilled at lumbar puncture in each case except that of the patient with an upper thoracic protrusion (*Case* 9) in whom the cisternal route was utilized. Two of the 7 patients with cervical protrusions submitted to the investigation showed an almost complete obstruction to the flow of dye (*Table III*). A third patient's (*Case* 7) pictures suggested the presence of an intramedullary tumour—though the lateral films gave a clue as to the true nature of the lesion. Two of the other 4 cases showed a lateral filling defect at the site of the protrusion while in one of the remaining 2 the diagnostic value of the procedure was reduced in that filling defects at 2 levels in the cervical canal were revealed —subsequent operative exposure demonstrating that at only one of these was a disk protrusion present. Two of the patients with dorsal protrusions showed a complete obstruction to the flow of the dye at the level of the affected disk and one a unilateral filling defect on the side of the lesion. The remaining patient had a calcified intraspinal mass and myelography was not required. One of the patients with a lumbar protrusion showed an almost complete obstruction to the flow of dye at the affected level. In the other the test was unsatisfactory in that a considerable amount of dye had been injected subdurally; there was probably a unilateral filling defect at the site of the lesion.

Surgical Treatment and Findings at Operation.—All the patients were operated upon in the prone position with the exception of one of the cervical protrusions (*Case* 5) in whom laminectomy was performed with the head and upper trunk in the upright position—this being maintained by skull traction. General anæsthesia—endotracheal N_2O, O_2, and either ether or trilene—was employed in all patients except *Case* 8 in whom the dangers of muscle relaxation and intubation were considered to preclude it. Here regional analgesia was obtained by infiltration with 0·5 per cent xylocaine—pieces of cotton soaked in the same solution being applied to the intrathecal posterior nerve-roots to minimize the pain occasioned in their manipulation in a conscious patient. Adrenaline in the concentration of 1 in 250,000 was added to the anæsthetic solution in this case and in all of the others infiltration with an adrenaline solution of the same concentration in saline was carried out to reduce blood-loss. A full laminectomy was done in each case—the number of spines and pairs of laminæ removed varying from 2½ to 5, the average for the 14 cases being 3½. It is considered that a wide exposure is required in order that trauma to the affected segments of the cord be minimized and also in order that what may be a relatively small anteriorly placed lesion be not overlooked. The fact that intervertebral disk protrusions may produce a severe neurological deficit when of relatively small size and that this deficit may develop acutely suggests that function is affected not simply by compression but that actual trauma to the spinal cord occurs. The frequent persistence of abnormal neurological signs after a protrusion is excised supports this view. During operation it is essential that the greatest gentleness be exercised in the manipulation of the dural theca and spinal cord if the already injured cord is not to be further traumatized—a happening which would appear to be far from uncommon when the results of operations for cord compression by disk protrusions in the literature are reviewed. In all of the cases the lesion has been exposed transdurally. Seven of the cervical protrusions were excised through a further incision in the anterior dura, and one was excised extradurally. Two of the dorsal protrusions were excised transdurally, the other two being removed extradurally after the relationship to the cord had been examined intradurally. One of the lumbar protrusions was excised transdurally and the other extradurally after intradural exploration. Median protrusions will be best excised transdurally whereas more lateral ones may be easily accessible extradurally.

The operative findings are summarized in *Table IV*. As regards the level of the 8 cervical protrusions 4 occurred at the interval between the 5th and 6th cervical vertebræ, 2 at that between C.4–5 and 1 each at the C.3–4 and C.7–T.1 intervals. Of the 4 dorsal protrusions 1 occurred at the T.2–3 level and the other 3 all at T.9–10. Of the 2 protrusions involving the conus 1 was at the T.12–L.1 level and the other at L.1–2. All of these protrusions should be classified as median, since they were related to the spinal cord itself, and thus distinguished from the lateral protrusions which affect one pair of nerve-roots (anterior and posterior) only. The term median does not imply, however, that the protrusion was invariably centrally placed in the spinal canal. In fact it was largely right-sided in 6 cases, largely left-sided in 5 cases, and in 3 it was bilateral. The weight of tissue excised in the 5 cervical protrusions in which this is recorded averaged 0·72 g., in the 2 dorsal protrusions 1·2 g., and in the 2 lumbar protrusions 2·9 g. The fact that the cervical protrusions were smallest, the lumbar ones largest, while the dorsal ones occupied an intermediate position is perhaps related to the total mass of the disks in each region, although the occurrence of calcification in the dorsal protrusions increases their density. Thus in the

young adult the total weight of a cervical intervertebral disk is less than half that of a thoracic disk and only a little more than one quarter of the weight of a lumbar disk. The tissue excised in the 2 cases of lumbar protrusion resembled normal fibro-cartilage and was not examined histologically. The gross appearance was similar in the case of the cervical protrusions. Three of these were examined histologically and one alone showed abnormality in the form of some calcification. Of the 4 dorsal protrusions 1 was composed of normal fibrocartilage and the other 3, at the T.9–10 level, were of extremely degenerate cartilage with much calcification and in 1 case ossification. It would seem likely that as intervertebral disk protrusions become more rigid as the result of calcification the risk of severe damage to the spinal cord, either spontaneous or at operation, increases and this may explain the poor results which have frequently been recorded in the literature following the surgical treatment of these lesions, especially in the thoracic region. Three of the cervical protrusions were small masses in the anterolateral portion of the spinal canal producing no displacement of theca or cord (*Table IV*); in another patient the cord was displaced to the opposite side while in the remaining four the extradural mass displaced the cord and theca dorsally and to one side. At four of the operations for cervical protrusions it was noted that the displacement of the cord within the theca was such as to obliterate the posterior subarachnoid space, and in 2 of these it was found at the termination of the operation that closure of the dura without risking compression of the cord was impossible so that the membrane was repaired with gelatin sponge. Of the dorsal protrusions 1 was a small mass producing no displacement of theca or cord, whereas in the remaining 3 displacement of these structures was marked. In 2 of these latter cases the dura over the summit of the protrusion was adherent to the arachnoid and in 1 of them in particular the protrusion was buried in a sharply localized excavation in the anterolateral column of the spinal cord. Both the lumbar protrusions formed large soft masses displacing the theca and conus dorsally and to the opposite side to some extent. In one of these the dura mater covering the protrusion was markedly injected and adherent to the pia arachnoid on the conus; in the other there was very marked lipping of the vertebral margins related to the affected disk.

Table IV.—Analysis of Operative Findings and Correlation with Pre-operative Functional Deficit

Case No.	Level and Side of Protrusion	Weight of Tissue Excised	Histology	Operative Appearance of Lesion	Effect of Lesion on Theca and Spinal Cord	Severity of Neurological Defect
1	C.3–4: R.>L.	?	Calcified fibro-cartilage	Small—anterolateral	Theca invaginated. Cord undisplaced	++
2	C.4–5: L.>R.	0·8 g.	Fibrocartilage	Medium size—antero-lateral	Theca invaginated. Cord → R.	+++
3	C.5–6: L.>R.	0·3 g.	Fibrocartilage	Small—anterolateral	Theca invaginated. Cord undisplaced	++
4	C.7–T.1: R.>L.	1·0 g.	—	Large—anterior and R. lateral	Theca and cord → posterior and to L.	++++
5	C.5–6: R.>L.	0·7 g.	—	Large—anterior and R. lateral	Theca and cord → posterior and to L. Subarachnoid space obliterated	+++
6	C.5–6: L.>R.	?	Degenerate fibro-cartilage	Small—anterior, with osteo-arthritic change. Œdema anterior roots	Theca invaginated. Cord undisplaced	++
7	C.4–5: R.>L.	?	Fibrocartilage	Large and bilateral	Theca and cord → posterior subarachnoid space obliterated	+++
8	C.5–6: L.	0·85 g.	Fibrocartilage	Large—anterior and L. lateral	Theca and cord → posterior and to R.	+++
9	T.2–3: L.>R.	?	Fibrocartilage	Small—anterior	Theca invaginated. Cord undisplaced	++
10	T.9–10: R.>L.	0·7 g.	Calcified degenerate fibrocartilage	Large—anterolateral, hard margins. Arachnoid-dural adhesions	Theca and cord → posterior and to L. Subarachnoid space obliterated	+++
11	T.9–10: L.>R.	1·6 g.	Calcified fibro-cartilage	Large—anterolateral, hard	Theca and cord → posterior and to R.	+++
12	T.9–10: R.>L.	?	Degenerate fibro-cartilage with ossification	Large—anterolateral, soft. Arachnoid-dural adhesions	Theca invaginated. Cord → posterior and excavated	++
13	T.12–L.1: L.>R.	3·5 g.	Fibrocartilage	Large. Arachnoid-dural adhesions	Theca invaginated. Conus → R.	+
14	L.1–2: R.>L.	2·3 g.	Fibrocartilage	Large, with gross osteo-arthritic change	Theca invaginated. Conus → L.	++++

The Results of Surgical Treatment.—Of the 8 patients with cervical disk protrusions one (*Case* 4)

died one week after operation (*Table V*). This man had developed an acute transverse lesion of the cord at the 7th cervical segment two weeks before he was referred for treatment. He was slightly dyspnœic on admission and post-operatively developed œdema of the lungs and a bronchopneumonia complicated by a right-sided empyema. His infection did not respond to chemotherapy. Of the remaining 7 patients with cervical protrusions 2 (*Cases* 7, 8) have been operated upon too recently to permit assessment of the end result, though both are making very satisfactory progress, having recently been discharged from hospital—*Case* 8 after plaster immobilization of the neck for a compression fracture of the 6th cervical vertebral body. The other 5 patients in the group have been improved by operation and have returned to work. *Case* 1 (C.3–4 protrusion) when last examined three years after operation complained only of some stiffness of the right shoulder and occasional tingling in his fingers. He was fully employed in his pre-operative occupation as an electrician and his only abnormal signs were weakness of abduction of the right arm and some residual increase of tone in the lower limbs. *Case* 2 (C.4–5 protrusion) had had to give up his work as an engine-driver and ten years after operation was still employed as a railway clerk, though active enough to maintain his small garden. He complained of tingling in the feet and a feeling of insecurity while walking and also that his hands tingled when he sneezed. When last examined his gait was slightly spastic but there was no motor deficit in upper or lower limbs, or any reflex abnormality. There remained a vague reduction of sensation in the lower limbs. *Case* 3 (C.5–6 protrusion) last reported by letter 3½ years after operation. He was then able to continue to earn his living as a violinist though he complained of tingling in his left hand and that the left fingers were stiff and clumsy. His left leg remained stiff and the toe of his left shoe quickly became worn down. *Case* 5 (C.5–6 protrusion) was greatly improved when last seen four years after operation. He was then at work as a gardener and cleaner in an army camp and could walk 2–3 miles daily. He complained of stiffness in the legs and right hand. Movements of the right hand were slow and there was spasticity of both lower limbs.

Table V.—RESULTS OF OPERATION

CASE NO.	LEVEL OF PROTRUSION	PAIN	POWER	SPASTICITY	SENSATION	PARÆSTHESIÆ	REFLEX DISTURBANCE	WORKING CAPACITY
1	C.3–4	Nil	Normal	+	Normal	Tingling in hands	Nil	Electrician
2	C.4–5	Cervical	Normal	+	Reduced vibration sensation, legs	Burning, R. leg	Nil	Clerical
3	C.5–6	L. arm	Reduced, L. hand	+ (L.)	Reduced pain and temperature, R.	Tingling, L. hand	Hyper-reflexia with plantar responses ↑↑	Violinist
4	C.7–T.1	—	—	—	Died	—	—	—
5	C.5–6	Nil	Slow R. arm	+	Normal	Numbness, legs	Knee-jerks and ankle-jerks ++. Plantar responses ??	Gardener
6	C.5–6	Nil	Normal	+	Reduced R. > L.	Nil	Knee-jerks and ankle-jerks ++. Plantar responses ↑↑	Foreman
7	C.4–5	Cervical stiffness	Sl. reduction R. finger movements	+	Normal	Nil	Inversion radial reflexes. Plantar responses ↓↓	Examination 7 weeks post-operatively
8	C.5–6	Cervical pain	Weakness L. finger movement	Nil	Reduced pain and temperature below D.2 R.	Nil	Inversion L. radial reflex	Examination while still in hospital, 4 weeks post-operatively
9	T.2–3	Nil	Normal	+	Normal	Nil	Tendon reflexes ++. Plantar responses ↑↑	Not known
10	T.9–10	Nil	Normal	+	Normal	Nil	Plantar responses ↓↓	Housewife
11	T.9–10	Nil	Normal	Nil	Reduced posterior column sensation	Nil	Nil	Taxi-driver
12	T.9–10	Nil	Normal	Nil	Normal	Nil	Nil	Roundsman
13	T.12–L.1	Back and leg	Normal	Nil	Normal	Nil	Reduced L. knee-jerk	Storekeeper
14	L.1–2	Nil	Reduced, R. ankle (++)	Nil	Reduced, R. leg	Nil	Absent R. knee-jerk and ankle-jerk. Plantar responses ↓↓	Nil

The tendon reflexes in the lower limbs were brisk but there was no clonus and the plantar responses were flexor. *Case* 6 was fully employed as a foreman bricklayer. Power in his legs had improved but there was subjective numbness of them; there was spasticity of the lower limbs with extensor plantar responses, the abdominal and cremasteric reflexes having returned. Pain sensitivity was reduced over both lower limbs.

The 4 patients with dorsal protrusions all did well—especially when it is recalled that recorded results in the literature on this group of cases have been far from encouraging. *Case* 9 operated upon in 1939 with a protrusion at T.2–3 cannot be traced. However, when discharged she complained only of some stiffness in the lower limbs. Examination then showed spasticity of the legs with increased tendon reflexes, ankle clonus, and extensor plantar responses. There was no sensory disturbance. *Case* 10—T.9–10 protrusion—when last heard of six years after operation was well and doing part-time work in a factory as well as caring for her home. She complained of some stiffness in the lower limbs. Her gait was normal and the only abnormal physical sign was a bilateral extensor plantar response. *Case* 11—a T.9–10 protrusion—was last examined five years after operation. He was following his pre-operative occupation as a taxi-driver, was symptom free and examination revealed no abnormal signs. *Case* 12—a T.9–10 protrusion—was recently examined four months after operation. He had returned to work as a roundsman three months after operation, was symptom free, and had no abnormal neurological signs.

Of the 2 patients with protrusions involving the conus medullaris *Case* 13, with a protrusion at the T.12–L.1 interval, was last seen three and a half years after operation. He was working as a storekeeper—instead of as machine operator and had lost eight weeks' work on one occasion because of backache and anterior crural pain on the left. On examination at this time he had full spinal movement and straight leg raising but the femoral nerve stretch test was positive. There was definite hypotonia of the muscles of the left lower limb but no loss of power; sensation was diminished below the 4th lumbar dermatome on the left and the tendon reflexes on this side remained weak. The other patient, *Case* 14, with a protrusion involving the conus medullaris at the L.1–2 interval, was last examined three years after operation when he was able to do a little work in the family business. The power and sensation in the lower limbs had increased considerably. There was slight vesical incontinence at night and occasional rectal incontinence. Examination then revealed a gross weakness of movement of the right ankle, apart from plantar flexion, as the outstanding motor deficit with sensation reduced below the 2nd lumbar dermatome on this side and absent knee- and ankle-jerks. He was able to walk short distances without a stick.

DISCUSSION

While an intervertebral disk protrusion is a space-occupying lesion within the spinal canal it differs in several respects, other than the obvious one of being non-neoplastic, from a spinal tumour. In the first place a protrusion of considerable size may develop in a matter of seconds and the possibility of accommodation of the mass by slow displacement and distortion of the cord such as occurs with benign neoplasms will not exist and intrinsic damage will be inevitable. Again the structure of a disk protrusion will frequently be more rigid than that of a neoplasm and being relatively fixed in the spinal canal it will be liable to injure the spinal cord when the latter moves over it as a result of vascular pulsations and alterations in spinal posture. Further disk protrusions are usually sharply localized masses and impinging upon the cord produce acute distortion over a small area while many neoplasms enlarging as they do in the long axis of the spinal canal produce a less abrupt displacement of nerve-fibres over perhaps several segments of the cord.

It has been indicated that intervertebral disk protrusions may produce either acutely developing traumatic lesions of the spinal cord or may more slowly compress it. Both the sudden injury and the slowly developing compression result from the application of mechanical forces to the spinal cord and these forces may affect both the nervous tissue at the level of the lesion and its blood-vessels. The effects upon nervous tissue will vary from a distortion of nerve-fibres without functional deficit to section of these fibres with permanent loss of function. The vascular changes will vary from local areas of capillary anæmia and œdema to hæmorrhage and thrombosis. In cases of slow compression of the cord the milder and reversible of these changes will develop whereas in the acute injury severe and irreversible changes will occur; cases of intermediate type clinically will exhibit both types of pathological disturbance. Both the severe acute traumatic syndrome and that of pure compression secondary to intervertebral disk protrusion are rare and in many cases the clinical picture is contributed to by both trauma and compression. This explains both the occurrence of a severe neurological deficit in the presence of a small disk protrusion and the frequent persistence of a neurological deficit of more or less severity after the excision of a disk protrusion. It may be that the occurrence of the electric shock sign and of tract pain, both of which have been discussed under the symptomatology of disk protrusions, likewise point to the element of trauma in cases in which compression of the cord by a disk protrusion appears to be the main feature. It has frequently been noted that when they come to operation, volume for volume, disk protrusions produce a more severe neurological disturbance than do benign extramedullary neoplasms and this is no doubt due to those characteristics in the case of a neoplasm which minimize injury to the cord. Further the same characteristics may explain the not uncommon experience that following the removal of extensive extramedullary growths with evidence of an almost complete transverse lesion of the cord full functional recovery may occur.

It has already been emphasized that this paper deals only with the involvement of the spinal cord by intervertebral disk protrusions and not by spondylosis. Confusion between these different types of lesion is suggested by perusal of certain papers dealing with involvement of the cervical cord and it must be stressed that cervical disk protrusions and cervical

spondylosis can be differentiated on grounds of pathology, clinical features, and therapy. Thus the protrusion is a mass of disk tissue at the level of one intervertebral joint and any degenerative changes in this joint are usually secondary to the occurrence of the protrusion. The mass of disk tissue compresses the related cord segment although it may, as has been seen, produce intrinsic damage in addition. Efficient surgical treatment will remove the factor of compression and will usually bring considerable benefit. Clinically these cases of cervical disk protrusion show clear evidence of a segmental lesion at the level of the protrusion. In cervical spondylosis the changes are essentially degenerative and usually involve several joints. Osteophytes projecting posteriorly impinge upon the cord and subject it to recurring trauma during neck movement—especially flexion. Clear cut evidence of a segmental cord lesion may be lacking in these cases and the results of surgical treatment often prove disappointing—although immobilization of the neck may bring considerable benefit. In operating upon cases of cervical spondylosis it has frequently been found that attempts to excise the bony spurs are fraught with such danger of cord injury as to render the attempt unjustifiable and the procedure may therefore achieve little; there having been no compression of the cord between the bony spurs anterior to it and the posteriorly placed laminæ, laminectomy itself can give rise to little benefit. It is possible, however, that in severe cases where the bony spurs are very large and where a complete block of the subarachnoid space occurs on extension of the cervical spine (Taylor, 1951) compression does occur. Even in such cases it seems likely that the traumatic factor will contribute largely to the clinical picture. Occasionally laminectomy for cord involvement in cervical spondylosis produces undoubted improvement, but immobilization of the cervical spine is the rational treatment in such cases and should be given a thorough trial before surgery is considered.

SUMMARY

1. Traumatic lesions of the spinal cord occasioned by intervertebral disk protrusions are discussed and examples of the different syndromes presented.

2. The literature dealing with compression of the spinal cord by intervertebral disk protrusions is briefly reviewed.

3. The records of 14 personal cases of compression of the spinal cord by intervertebral disk protrusions in the cervical, dorsal, and lumbar regions are analysed.

4. The aetiology of the protrusions in this series and the clinical features produced by them receive detailed consideration.

5. The value of accessory methods of investigation is assessed.

6. The surgical treatment of intervertebral disk protrusions so placed as to involve the spinal cord is discussed and the results of treatment in the present series is considered.

7. The pathological nature of the disk lesion is correlated with the clinical features which it produces and the results of surgical treatment.

8. The distinction between cases of cord compression by intervertebral disk protrusion and its involvement in spondylosis from the pathological, clinical, and therapeutic aspects is stressed.

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ADENOMATOUS TUMOURS OF THE ANTERIOR FOREGUT REGION SHOWING THE CYLINDROMA PATTERN

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INTRODUCTION

THIS study of the adenomatous tumours of the anterior foregut region is based upon the collection of tumours which, during the past ten years, have been filed under the headings 'adenomas' and 'mixed adenomas' in the Pathology Department of the Christie Hospital in Manchester.

In this hospital tumours of the anterior foregut may reach the pathologist from various sources, namely, the general surgeon and the otolaryngological, thoracic, ophthalmic, and dental units. The majority of the specimens are obtained from the sites of the large serous salivary glands, that is to say from the parotid and submaxillary regions; but as the years have passed the collection of adenomas from ectopic, or aberrant, sites has accumulated, and tumours from the palate, cheeks, floor of mouth, antrum, tongue, tonsillar region, pharynx, lacrimal gland, and the trachea and bronchi, have been seen. Sometimes several tumours from ectopic sites were received each year, but in the rarer sites only one in several years, and only one adenomatous tumour of the trachea was seen in ten years.

The review of the ten years' collection was undertaken for two reasons; first, because occasionally metastases had been received from cases in which the primary lesion had been included in the non-malignant, 'mixed adenoma' category, and, secondly, because members of the oto-laryngological unit were concerned with the unsatisfactory course and grave ultimate prognosis in some of the adenomas occurring in ectopic sites. At first it was assumed that inaccessibility of site was responsible for the grave prognosis in the unusually situated tumours, but more careful investigation showed that this idea was not tenable for reasons which will be given later. It was decided, therefore, to restudy all the histological material combined with the clinical follow-up data.

No case was included in the series of which an adequate histological preparation was not available in the laboratory collection. This was particularly necessary in specimens from the ectopic sites from which biopsy material is more likely to be inadequate than from the large serous salivary gland sites. Any wastage of material from this decision was counterbalanced by the importance of seeking a true prognosis based upon histological pattern. No attempt has been made to assess the general incidence of these tumours, because the Christie Hospital patients are highly selected from a population of over four million people, and they are gathered together because of the centralization of radio-therapeutic plant in this region of England.

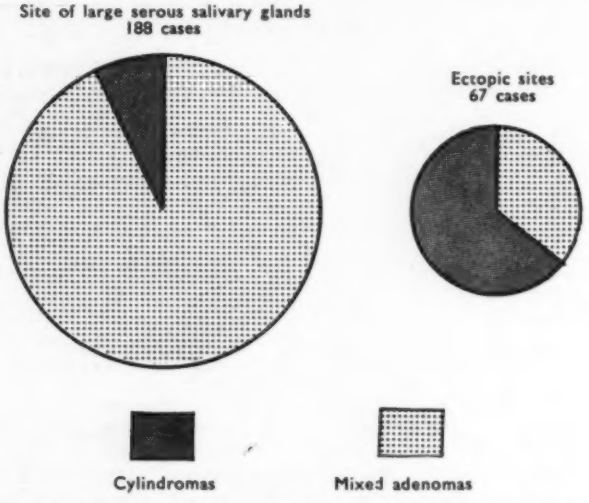

FIG. 288.—Classification of 255 cases according to site and histological type.

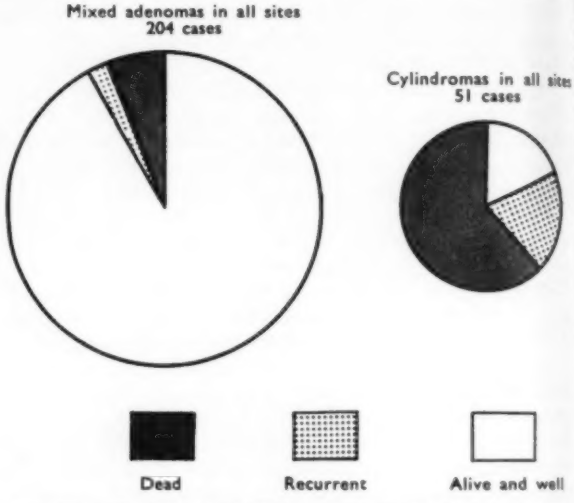

FIG. 289.—Prognosis in mixed adenomas and cylindromas. Follow-up details of ten years' cases (1944–53) compiled in 1954.

The following section will provide the data from this survey, which led us to separate adenomas showing the *cylindroma* pattern from those of the mixed adenoma group, and which indicated that cylindromas are commonest in the ectopic sites, and have a grave ultimate prognosis. They appear to arise in the ducts of the mucous, rather than serous, salivary glands. Their mode of spread is that of a rodent tumour, giving relentless local recurrences, and occasionally late distant metastases. The clinical aspect of some of these cases has been published already (Harrison, 1955). Their course is distressingly slow, and inoperable recurrences with survival for many years, without either gland or other metastases, are quite numerous.

The history of the subject is so confused that it will be dealt with in a later section rather than as an introductory paragraph.

MATERIAL AND ITS ANALYSIS

During the decade under review, over five thousand histological specimens of all types (the majority of them tumours) from the anterior foregut region were reported upon, and among these the adenomas numbered 272. Of this total 204 were mixed adenomas, 51 showed the cylindroma pattern, 5 cases contained both these patterns, and 12 were

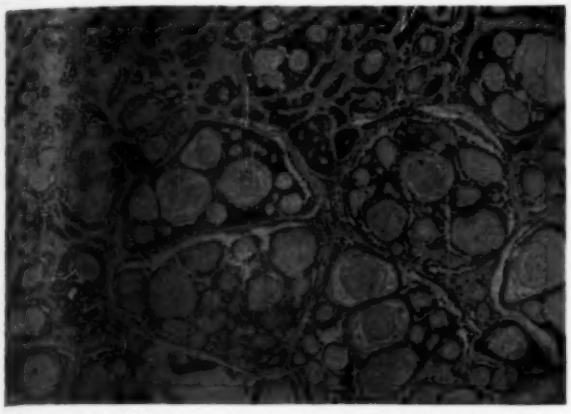

FIG. 290.—Cylindroma pattern in tumour of lacrimal gland. (*By courtesy of Dr. E. K. Dawson.*)

classed as 'other adenomas'. *Table I* gives their distribution, sex incidence, and survival rate in 1954. This paper is concerned with the 256 cases of the first two categories in *Table I*, but it may be noted that those of the third category are too few for study, and those of the fourth category, 'other adenomas', showing neither the mixed adenoma nor the cylindroma pattern, present unsolved difficulties in classification.

Figs. 288, 289 illustrate the distribution of the 256 tumours between the large serous salivary gland sites and the ectopic sites, and show that the cylindromas are commoner in the ectopic sites, and have a much worse prognosis than mixed adenomas in the same sites. The palatal tumours alone illustrate this well :—

Palatal tumours of mixed adenoma type = 18—of which 17 were alive and well in 1954 ;

Palatal tumours of the cylindroma pattern = 17—of which 7 were alive in 1954, and of these 6 were inoperably recurrent. These figures prove that inaccessibility of site is not responsible for the grave prognosis of the cylindromas, because the mixed adenomas of the palate have been treated successfully when compared with an equal number of cylindromas which were unsuccessful.

HISTOLOGY

The histological diagnosis of the cylindroma depends, as in most tumours, upon the recognition of a tissue pattern, rather than upon the shape and size of individual cells. *Figs.* 290–294 illustrate this pattern in its most characteristic forms, and *Figs.* 297, 298 show modified forms in the rare distant metastases, of which we have only four examples in the ten years' histological collection, although the incidence of metastases is probably much higher.

The tumour is essentially an adenoid structure, which appears to arise from dilated mucous gland ducts whose epithelium shows degenerative metaplasia of the cubical lining cells into small polygonal cells which have very little protoplasm. These small cells, of which the tumour consists, are about the size of the basal cells of the epidermis, but rounder, and as

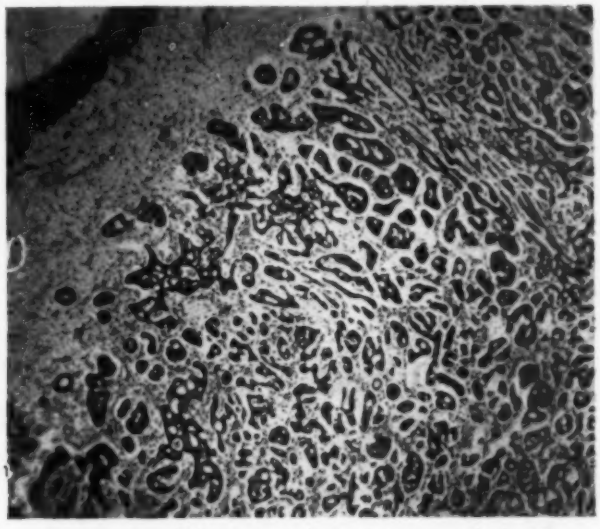

FIG. 291.—Cylindroma palate of two years' duration treated by radium mould and implant in 1938. Excision of hard palate for recurrence in 1950. Further operation for removal of tumour in antrum and nasal cavity in 1954. (× 30.)

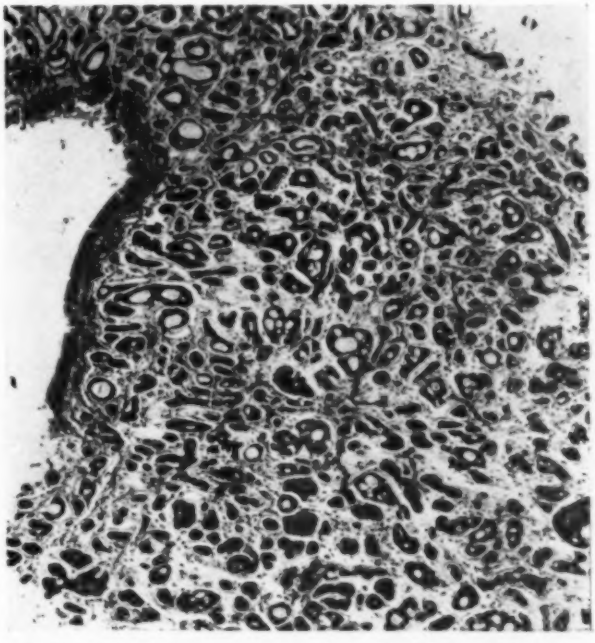

FIG. 292.—Adenoma of bronchus (cylindroma pattern) residual after several operations over five years.

Krompecher pointed out, they are like the cells of many basal cell skin tumours. They are arranged around duct-like spaces or are packed closely within the spaces in columns and drifts of cells, and the spaces containing degenerate mucoid material stand out as round holes in the sections, giving the 'adenoid cystic' appearance of some authors (*Fig.* 290). The density of closely packed cellular tissue, and the amount of the supporting stroma, vary very much and

Table I.—ADENOMAS OF ANTERIOR FOREGUT REGION, 272 CASES

YEAR	MIXED ADENOMAS				CYLINDROMAS				MIXED ADENOMA AND CYLINDROMA COMBINED				OTHER ADENOMAS			
	Site	No. of Cases	Well or Recurred in 1954	Sex	Site	No. of Cases	Well or Recurred in 1954	Sex	Site	No. of Cases	Well or Recurred in 1954	Sex	Site	No. of Cases	Well or Recurred in 1954	Sex
				M. F.				M. F.				M. F.				M. F.
1944	Parotid	15	13	6 9	Palate	3	1 + 1 rec.	2 1	Palate	1	1	0 1				
	Lacrimal	1	1	0 1	Tongue	1	0	0 1								
1945	Parotid	15	15	3 12	Parotid	2	0	0 2					Palate	1	1	0 1
	Palate	3	3	1 2	Palate	4	0 + 1 rec.	2 2					Post-nasal space	1	?	1 0
					Nasopharynx	2	0	0 2								
					Antrum	1	0	1 0								
1946	Parotid	15	14	3 12	Parotid	1	0	0 1								
	Palate	1	1	0 1	Sublingual	1	0	1 0								
	Submaxillary	1	1	1 0	Tongue	1	0	1 0								
					Bronchus	1	1 rec.	1 0								
	Lip	1	1	1 0	Palate	1	0	0 1								
1947	Parotid	18	16 + 1 rec.	9 9	Parotid	2	1 rec.	1 1					Cheek	1	1	0 1
	Palate	4	4	1 3												
	Lacrimal	1	1	0 1												
1948	Parotid	24	22	10 14	Parotid	2	1	1 1					Parotid	1	1	1 0
	Palate	1	0	1 0	Palate	1	0	1 0					Fauces	1	1 rec.	0 1
	Lip	1	1	0 1	Tongue	2	0	0 2								
	Submaxillary	2	1	2 0	Fauces	1	0	1 0								
					Mouth floor	1	0	0 1								
1949	Parotid	20	20	6 14	Palate	1	1 rec.	0 1					Palate	1	1	1 0
	Palate	2	2	0 2												
	Submaxillary	1	1	0 1												
1950	Parotid	15	15	6 9	Palate	1	1 rec.	0 1					Parotid	1	1	1 0
	Palate	2	2	1 1	Tongue	1	1	0 1								
	Submaxillary	1	1	0 1	Lip	1	0	1 0								
					Mouth floor	1	0	0 1								
					Pterygo-mandibular	1	0	0 1								
					Tonsil	1	1 rec.	0 1								
1951	Parotid	16	16	11 5	Parotid	1	1	1 0	Palate	1	1	1 0	Palate	1	1	0 1
	Palate	2	2	2 0	Tongue	1	0	0 1	Submaxillary	1	1	0 1				
	Lacrimal	1	1	1 0	Palate	1	0	1 0	Parotid	1	1	0 1				
	Tonsil	1	1	1 0	Submaxillary	1	0	0 1								
	Submaxillary	1	0	1 0	Nasopharynx	1	1 rec.	0 1								
	Mouth floor	1	1	0 1	Ethmoid	1	0	0 1								
					Antrum	3	1 + 1 rec.	3 0								
1952	Parotid	17	17	3 14	Palate	1	0	1 0					Parotid	1	0	1 0
	Palate	1	1	1 0	Lip	1	1	0 1					Cheek	1	1	1 0
					Antrum	1	1	0 1					Submaxillary	1	1	0 1
1953	Parotid	17	17	9 8	Palate	4	2 + 1 rec.	3 1	Antrum	1	1 rec.	0 1	Parotid	1	1	0 1
	Palate	2	2	0 2	Mouth floor	1	0	1 0								
	Tonsil and parotid	1	1 isq.	0 1	Submaxillary	1	1 rec.	0 1								
					Trachea	1	0	0 1								
	TOTALS	204	193 1 rec. 1 isq.	80 124		52	8 11 rec.	22 29		5	4 1 rec.	1 4		12	9 1 rec.	6 6

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may lead to difficulty in distinguishing cylindromas from mixed adenomas in small biopsies. Mitoses are not at all numerous. *Fig.* 296 stained by the periodic-acid Schiff method, shows the successive zones or cylinders which were the source of the descriptive term 'cylindroma'. Thus, there is a central blob of mucous surrounded successively by a hyaline ring, a ring of cells, another hyaline ring, and finally the fibrous stroma which also assumes a cylindrical or tubular shape. These details are seen especially in the oldest parts of the tumours.

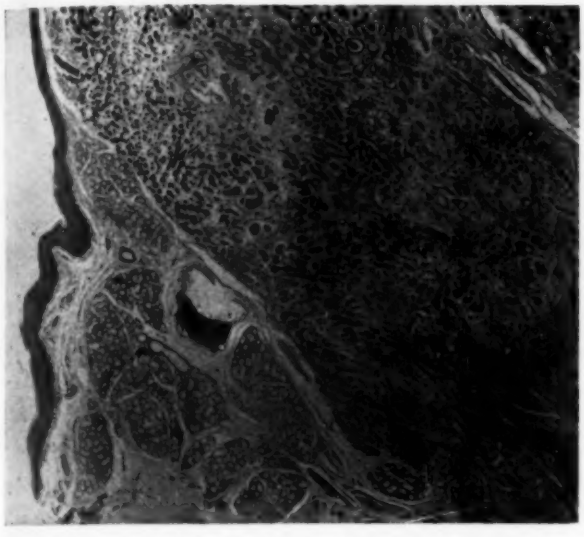

FIG. 293.—Cylindroma dorsum of back of tongue. Two years' history. Excised and treated by irradiation. Re-operation a year later. Died four years after the initial treatment with local necrosis and clinical metastases in glands and lungs.

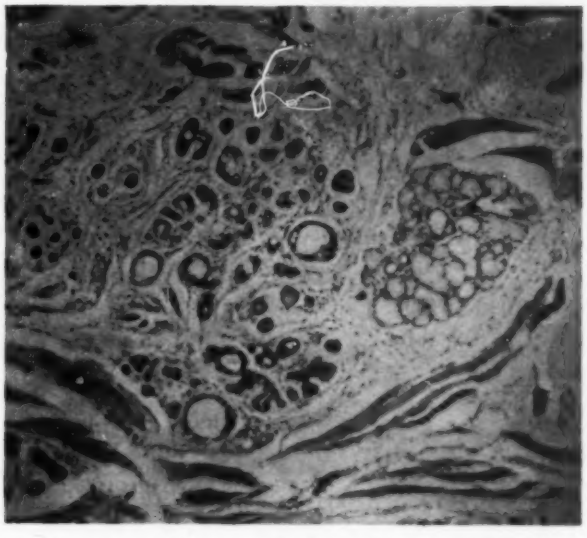

FIG. 294.—Higher magnification of *Fig.* 293 to show the relation of the tumour to mucous glands and its apparent origin from their ducts.

When the mucous glands surrounding the tumour are available for examination it is possible to trace the origin of the neoplasia to the mucous gland ducts. *Fig.* 293 is a low magnification of the back of the tongue, in which healthy mucous glands are seen lying loosely between muscle bundles. The tumour is embedded in the same way and is seldom encapsulated as are the mixed tumours of the large serous salivary glands.

The mixed adenomas from which the cylindromas have to be distinguished show a variety of patterns which depend upon a curious process of autodigestion in which areas of mucoid material emerge, and in which cartilaginoid and myxomatous metaplasia may develop. The epithelial cells scattered about in this mucoid or fibro-mucoid matrix appear to lose their polarity. This inextricable intermingling of mesenchymal and epithelial elements undergoing degenerative changes has been responsible for the great confusion in the histological descriptions of mixed adenomas, both before and since modern fixation and staining methods became available.

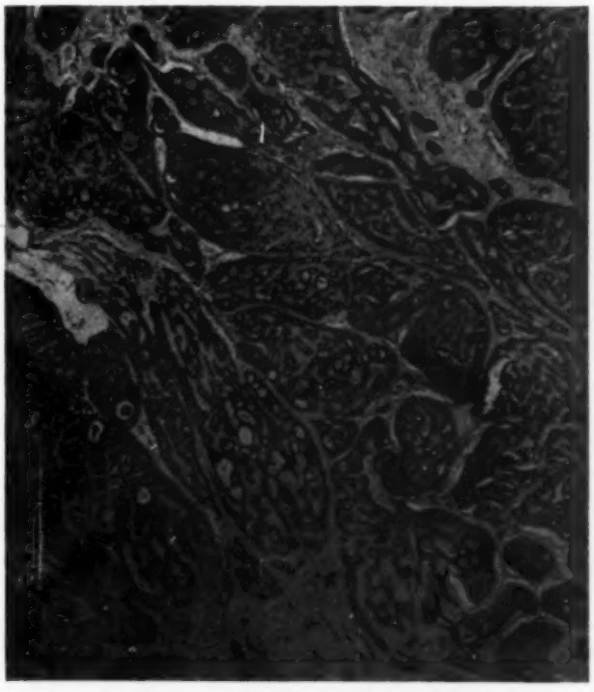

FIG. 295.—Tumour of antrum and palate treated by surgical excision. No recurrence recognized in four years. (× 50.)

HISTORICAL SURVEY

The history of the pathology of the foregut adenomas is one of the particularly confused chapters of medical investigation, the beginnings of which did not forecast the ultimate confusion, for in 1859 Billroth described salivary adenomas, of which he had seen about twenty cases in various sites. He used the term cylindroma to describe the histology of one of these, and, from his descriptions, others were undoubtedly mixed adenomas. He gave details of one case, a tumour of the cheek, which had been followed for 23 years, and which was operated upon nine times and finally remained untreatable.

After that time cases were published under different names, and for years much discussion ensued as to whether the cells in these tumours were epithelial or endothelial in origin. Boettcher (1867,

1868) called them 'schlauchknorpel geschwülst cylindrome', which to-day would mean that they were both mixed tumours and cylindromas. Koestler (1867) described 'cancroids' which he decided were the same as Billroth's cylindromas: one

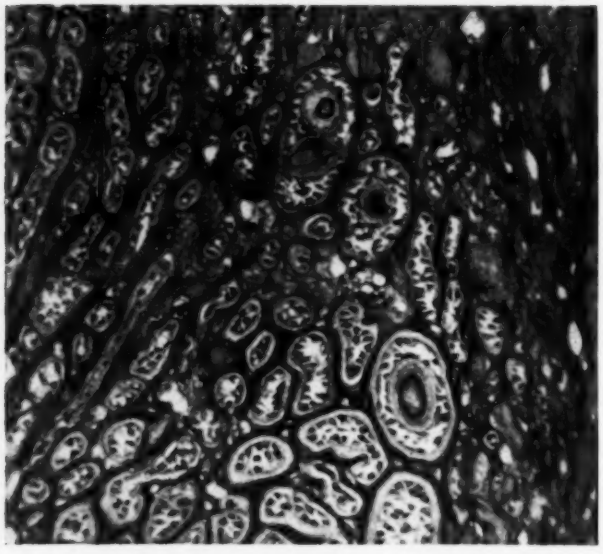

FIG. 296.—Cylindroma of palate stained by the periodic-acid Schiff method to show the details of the pattern.

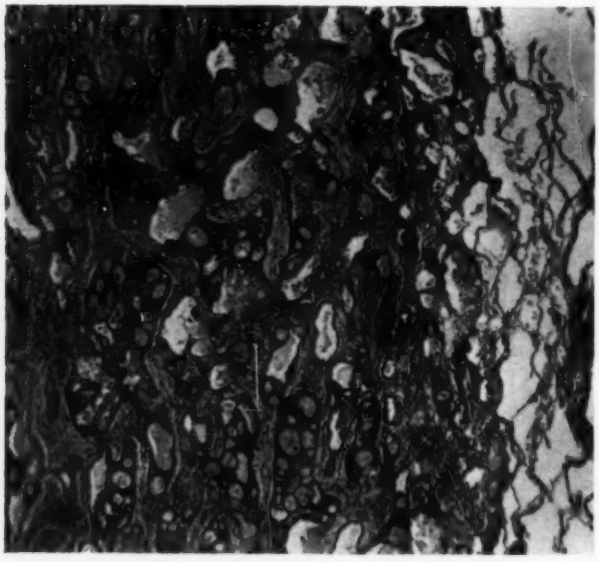

FIG. 298.—Silent metastasis in lung from a cylindroma in the region of the tonsil. History.

of his cases was in the sublingual region, and the other at the angle of the eye. In 1872 Waldeyer recognized that parotid tumours were the most 'mixed' of all tumours, and compared them with mixed tumours in other organs. By 1883 Malassez was able to collect eleven synonyms for what he accepted as a cylindroma, but preferred to call them 'epitheliomes alveolaires avec évahissement myxomateux'. He added two cases of his own, one from the palate, and one from the submaxillary region.

In a study of tumours of the palate, Stephen Paget (1886) recognized that many of them were like parotid mixed tumours, and he accepted their heterogeneous appearance as supporting Conheim's theory of tumour genesis. He classed thirty-one cases as adenomas, none of which, although of many years' duration, showed any metastases. Wood, in

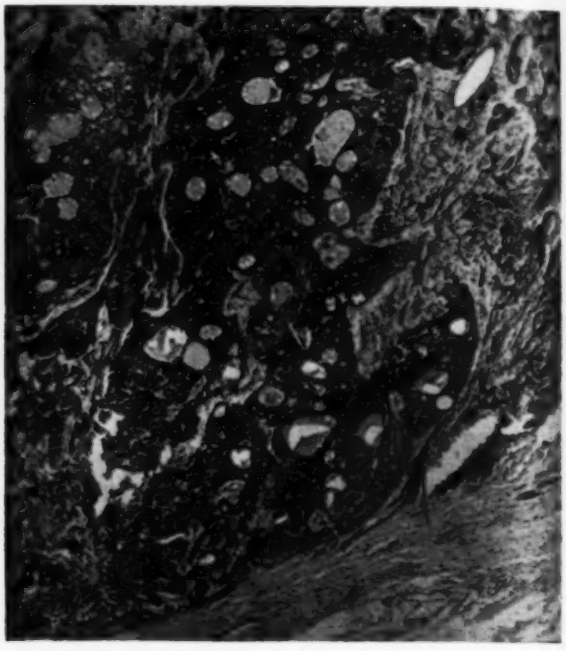

FIG. 297.—Metastasis in ilium from cylindroma in pterygomandibular region. History of deafness for ten years, now ear discharge and swelling of the face and neck on the same side. Treated by X rays. Removal of neck glands a year later and local recurrence recognized and also this bone deposit. (× 30.)

1904, wrote a long discussion on mixed tumours of the salivary glands. He had seen forty-seven cases in various sites, and used the term cylindroma for one, but attached no prognostic significance to it. Ribbert gave an authoritative ruling on what the word cylindroma meant in 1907, indicating that the cylindromatous tissue layers involved both the epithelial structures and the supporting stroma (*Figs.* 295, 296). He believed that they arose in the ducts of mucous glands and quoted one case where the tumour had spread slowly from the palate to the base of the skull, and had finally metastasized to the lungs. Krompecher (1908) reviewed the whole subject about the same time, under the heading 'Bazalzellen Krebs', in which he included both cylindromas of mucous membranes and basal cell skin tumours.

From about this date readers find it increasingly easy to understand what histological pattern is involved in descriptive papers because of the great improvement in methods of illustration. Blumenfeld (1914) published the description of two heterotopic mixed tumours of the lip, one of which appears to have been a mixed adenoma, and the other a cylindroma. Patey in 1930 made a histological study of fifty-five salivary gland mixed tumours and noted the confused terminology: no follow-up data were included in his paper. In the same year Brunschwig described and illustrated two cylindromas, from the tongue and sublingual regions, of seven and seventeen years' duration respectively. Spies (1930)

followed twenty-nine cases of what he called cutaneous and non-cutaneous adenoid cystic carcinomas, three of which developed metastases, and the illustration of one of these is undoubtedly a cylindroma. He found the non-cutaneous group of these adenoid cystic tumours had a very much worse prognosis than the cutaneous group. New and Childrey (1931), in surveying tumours of the tonsil and pharynx, wrote of adenocarcinomas of mixed type which did not recur or metastazise. Leroux and Leroux (1934) subdivided the salivary gland tumours into fourteen varieties. In Ahlbom's monograph (1935) on mucous and salivary gland tumours, cylindromas were classed among the semi-malignant tumours, and he called them ' basaliomas '. Lemâitre, Andoin, and Lemâitre (1936) took up the word cylindroma again in the study of ectopic adenomatous tumours found in the skin and mucous membranes of the head region, and thought *d'aspect cylindromateux* might be applied to them and that cylindroma should be given up.

It was about this time that adenomas of the bronchus became widely recognized, and in a paper by Jackson and Konzelmann (1937) twelve cases were described. One of the illustrations is a cylindroma. In 1938 Harvey, Dawson, and Innes reviewed a large collection of mixed tumours of the salivary glands and decided that it was wisest to class them all as adenomas. There was no follow-up record of cases in this review, and those of the cylindroma pattern were not given any prognostic connotation.

Ringertz (1938) in the monograph on the malignant tumours arising in the nasal and para-nasal sinuses employed the word ' basalioma ' as Ahlbom had done, and divided them into cystic and solid : his illustrations are those of the cylindroma pattern. In 1939 Kramer described six cases of cylindroma of the upper air passages, and Foster-Carter (1941) summarized the literature on bronchial adenomas to date, adding twenty-two of his own. He noted that they occurred most frequently in women, and it appears from his illustrations that adenomas of the cylindroma pattern were in his series.

Mulligan (1943) collected data of metastases from mixed tumours, and said that the cylindroma pattern was correlated with the tendency to metastasize. His own case was a tumour of the parotid of thirteen years' duration, which eventually metastasized to bone and internal organs.

Tinney's review (1945) of the tracheal tumours seen in the Mayo clinic over ten years included eight cylindromas, and all had a relatively good prognosis.

McDonald, Moersch, and Tinney (1945) saw forty-four adenomatous tumours of the bronchus, of which six were classed as cylindromas.

Quattlebaum (1946) discussed what he called adenocarcinomas of cylindroma type in the parotid gland, and indicated that the pathologist could be of real help to the surgeon by recognizing its specific pattern because of its tendency to recurrence and metastases. Of 20 cases only 5 were alive and well after five years, and 4 others had a history of prolonged recurrences ; the others were dead.

McDonald and Havens (1948) studied a large number of glandular neoplasms of the lips, nasal, and para-nasal cavities, and emphasized that the five-year survival rate of the cylindromas was better than that of the adenocarcinomas, but that their ultimate prognosis was worse.

Belsey and Valentine (1951) described the histology of three cylindromatous mucous gland tumours of the trachea and bronchi, and, discussing their similarity to salivary gland tumours and basal cell skin cancers, emphasized their local invasive tendencies, although they rarely metastisized. They suggested that cylindromas should be classified as a special subgroup of the mucous gland tumours of the trachea and bronchi.

Pollack (1952) described two slowly growing cylindromas as ' relentlessly recurring ' tumours ; one was in the nasopharynx, and the other in the antrum. This epithet, ' relentless recurrence ' sums up the clinical course of the tumour very ably.

In Foote and Frazell's study (1953) of over 500 tumours of the major salivary glands 34 of the adenoid cystic carcinoma type are included, and they were cylindromas as judged by the pictures.

These references are a selection from many papers which indicate that some workers have recognized a clinical entity among the adenomatous tumours of the anterior foregut region, and this is especially true of the oto-laryngological units within the last twenty years. Cylindroma appears to be the name under which it is most commonly described. The surgical pathologist can give substantial assistance to the surgeon by recognizing its pattern, because it is correlated with insidious infiltrative growth and grave ultimate prognosis.

DISCUSSION

It has never been easy to assess the malignancy of the relatively well differentiated adenomatous tumours. Over a hundred years ago the problem emerged in the study of breast neoplasms, and as soon as cellular pathology was established the adenomatous tumours of other organs, especially those of the skin, thyroid, ovary, and salivary glands, illustrated the same difficulties.

To-day the difficulties remain, and for various reasons. One of them is the comparative rarity of adenomas : one worker may not see more than half a dozen cases from one site in a lifetime's work. Further, without the support of a clinical follow-up record system, it is impossible to correlate a histological pattern with ultimate prognosis and survival time. A third factor which adds to diagnostic difficulties is the inadequacy of biopsy material which may be too small to include the relations of a tumour to its surroundings, or be distorted by sepsis and previous treatment. The scattering of histology material throughout the laboratories of different surgical units also prevents any wide view of tumour pathology being established. However, in radiotherapeutic centres it is still possible to investigate a wide range of material from the sites of the ' accessible cancers ' at least. It is from a survey of ten years' collection of specimens from accessible cancers that the cylindroma has emerged from among the mixed and other adenomatous tumours as a histological and clinical entity. It is also clear from the literature of the last fifteen to twenty years that some workers, in oto-laryngological units particularly, have increasingly recognized the importance of identifying this tumour on account of its grave

prognosis. It is not clear, however, from the literature, that surgeons and pathologists as a whole have realized the prognostic importance of its histological characters.

Whether this neoplasm is essentially of mucous gland rather than of serous salivary gland origin is difficult to say, but it seems likely that anatomical and physiological differences may account for its clinical and histological peculiarities.

The serous salivary gland tissue of the anterior foregut region is concentrated in the parotid and submaxillary regions where the mixed adenomas are commonly found; and although there are also serous elements in the vallate papillæ of the tongue and in the sublingual region, the main glands of the mucous membranes of the oral, nasal, and paranasal cavities are of the mucous type. And we have shown that it is in the buccal and nasal cavities that the cylindromas are usually situated.

It is noteworthy that adenomas of both mixed and cylindroma pattern are commoner in women than in men, the proportion being about 3 : 2.

SUMMARY

A survey of ten years' collection of adenomatous and mixed adenomatous tumours of the anterior foregut region showed that those of the cylindroma pattern bear a worse prognosis than those of the ordinary mixed adenoma types. The cylindromas appear to arise in mucous rather than in serous salivary gland tissue, and are commonest in the ectopic, or aberrant sites. They have been obtained from the lacrimal gland and from the whole respiratory tract, from lips and nose to the bronchi.

Their grave prognosis does not depend upon inaccessibility, but rather upon the fact that frequently they are not well encapsulated as are the adenomas in the large serous gland sites.

The mode of spread of a cylindroma is that of a relentlessly recurring rodent tumour and invasion of the base of the skull may occur before distant metastases arise. A few such distant metastases are illustrated.

It is suggested that the name cylindroma be accepted for this tumour, as it is now correlated with a special clinical picture and prognosis. No advantage can accrue from classifying it among the frank carcinomas which run a different morbid anatomical and clinical course.

The surgical pathologist substantially aids the surgeon by recognizing it because the general consensus of surgical opinion in the literature emphasizes the need for early radical excision. There is no evidence that it is a radio-sensitive lesion.

I have to thank Professor Victor Lambert and Mr. Kenneth Harrison for close co-operation in this review, the latter supplied me with the clinical data of the cases. To Dr. E. K. Dawson I am indebted for permission to study the bronchial adenomas in the histology collection of the Royal College of Physicians Laboratory in Edinburgh, and also for giving me *Figs.* 290 and 292 from that collection.

To Mr. E. J. Higgins I am grateful for many histological preparations, and to Mr. F. Wardlaw for the photographs.

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ADAMANTINOMA

A BRIEF REVIEW OF THE CONDITION, WITH A DESCRIPTION OF A CASE TREATED BY IMMEDIATE REPLACEMENT WITH A TANTALUM AND ACRYLIC PROSTHESIS FOLLOWING RESECTION OF THE AFFECTED AREA OF THE MANDIBLE

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ADAMANTINOMA, also known as ameloblastoma, epithelial odontome, and multilocular cyst, is a slowly growing, locally invasive, neoplasm of epithelial origin which occurs principally in the jaws, and is most commonly situated in the third molar region of the mandible.

Malassez (1885) considered that the condition arose from aberrant proliferation of ectodermal cell rests or debris derived from the inclusion within the periodontal membrane or adjacent alveolar bone of those cells surplus to the formation of the enamel organ of the tooth which persist following the completion of the final phase of amelogenesis. The normal development of the three permanent molar teeth, which have no deciduous predecessors, takes place by virtue of a backward prolongation of the dental lamina or anlage, calcification of the first molar tooth occurring at about the time of birth, that of the second molar tooth at the third year of age and a similar process ensuing in the case of the third molar or wisdom tooth at approximately nine years of age. As previously mentioned, it is in this latter region that the condition of adamantinoma is most frequently observed, and for this reason the view is often expressed that the neoplasm is a reflection of aberrant growth or malformation of the developing enamel organ. Cahn (1933) has reported an adamantinoma originating from a mural swelling arising from the wall of a dental or dentigerous cyst, and this phenomenon has been observed by one of the authors (N. L. R.) in two instances. Champion, Moule, and Wilkinson (1951) have published a case in which histological section showed the origin of an adamantinoma directly from the basal layer of the oral epithelium, and a similar case has been recorded by Villa (1953).

Neoplasms which exhibit a similar histological picture to that seen in the adamantinoma of the jaws have been described in the hypophysis by Critchley and Ironside (1926), and also in the tibia by Baker and Hawksley (1931).

PATHOGENESIS

Although a distinct and characteristic histological pattern may be said to occur, a large number of cases manifest a wide variation in their cellular morphology, and the reasons for this can only be fully appreciated if the development of a normal tooth is considered in some detail together with a comparison of the origin of a basal-cell carcinoma from the rete Malpighii.

A tooth germ is formed simultaneously by a direct downgrowth of the basal layer of the primitive oral ectoderm into the mesenchyme of the jaw, whilst active proliferation and condensation of certain of these mesenchymal cells take place to form a dentinal papilla. The enamel organ then differentiates into two layers, an inner and outer enamel epithelium separated by a stellate type of

FIG. 299.—Developing tooth germ at approximately the twenty-sixth week of intra-uterine life.

reticulum, the whole structure assuming the shape of a bell (*Fig.* 299). Only the inner enamel epithelium possesses the characteristic columnar shape of the future ameloblast or enamel-forming cell, the remainder of the cells being cuboidal. The actual formation of enamel and dentine provides an example of the action of an organizer or inductor similar to that seen during other phases of embryological development whereby the growth and differentiation of one group of cells is mutually dependent upon the presence of another group. This arrangement ensures that no enamel is formed without the presence of the dentinal papilla and its differentiated dentine-forming cells, the odontoblasts, and as an adamantinoma is essentially of epithelial derivation, *no enamel formation* ensues following neoplastic proliferation of its constituent cells.

In the case of the skin, the basal or germinal layer may differentiate in either of two directions ; towards

the surface to form flattened or squamous cells which ultimately degenerate to form the protective keratin layer, or towards the dermis to develop into the skin appendages such as the hair follicles and sweat-glands. Any neoplastic proliferation of the former type of cell will result, if malignant, in the formation of a squamous-cell carcinoma, whilst a similar

FIG. 300.—Photomicrograph taken from the excised specimen shown in *Fig.* 304. Solid cords of epithelial cells are invading the surrounding tissues in a manner comparable to the dental anlage. (× 210.)

proliferation of the latter variety of cell will produce one of the varieties of basal-cell carcinoma which Foot (1947) so aptly refers to as tumours of the skin adnexæ.

The cells of the skin which normally differentiate into squamous cells, or sweat-glands and hair follicles, have their counterpart in those cells of the mucous membrane of the mouth which may develop into either simple stratified squamous epithelium lining the oral cavity, or a component of the odontogenic tissue, the enamel organ, and the anlage of the mucous salivary glands. The inclusion within the mesenchyme or bone of the jaws of a considerable amount of residual epithelial tissue derived from tooth formation may from time to time give rise to aberrant structures resulting from proliferation of these cells. Thus, in the simplest form, growth of epithelial cells included within the periodontal membrane of a tooth will produce a dental cyst; active growth of the outer enamel epithelium instead of quiescence or atrophy will result in the formation of a dentigerous cyst; whereas neoplastic growth will give rise either to an adamantinoma if a locally malignant condition comparable to a basal-cell carcinoma occurs, or an intra-alveolar epidermoid carcinoma. This latter condition, which is highly malignant, is comparatively rare, and should not be confused with carcinoma of the gingiva invading bone or a secondary deposit in the jaws; it arises, as the name suggests, as a primary growth within the bone. Matheson (1951) has described the condition under the heading of 'primary carcinoma of the mandible', the patient succumbing some nine months after attention had been drawn to the condition by a spontaneous or pathological fracture.

McWhirter (1950) regards adamantinoma as being essentially a basal-cell carcinoma of the mucous membrane of the mouth, and Willis (1948) refers to the condition as 'carcinoma of the tooth-germ residues'.

HISTOLOGICAL CHARACTERISTICS

A typical adamantinoma closely resembles the developing enamel organ in its cellular morphology and histological pattern, but sections taken from different areas of the same neoplasm will vary considerably. In some regions columns of cells may be observed growing down into the mesoderm

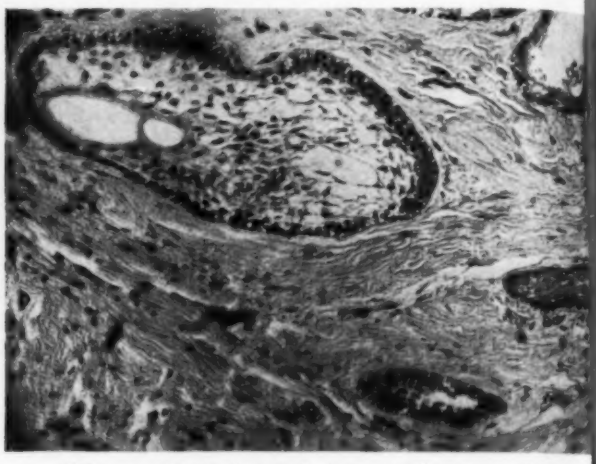

FIG. 301.—Photomicrograph from another area of the same specimen shown in *Fig.* 300. This shows the typical appearance with columnar cells forming a palisade around a stellate reticulum, in the centre of which cellular degeneration has formed a cystic cavity. (× 300.)

in a manner reminiscent of the primitive dental lamina (*Fig.* 300), whilst in others columnar cells similar to those seen in the inner enamel epithelium form a palisade around a characteristic stellate reticulum. Eventually the larger clumps of cells break down in the centre of this stellate reticulum to form cystic spaces, many of which coalesce (*Fig.* 301).

The variable manner in which the normal basal layer of the primitive stomatodæum may differentiate has its counterpart in the pleomorphic characteristics observed in the histological study of adamantinomata. The presence of squamous cells is relatively frequently noted constituting the acanthomatous variety of the condition, and adenomatous, fibrous, melanotic, and solid cellular types have been recorded. The latter tends to occur in the maxilla when it is indistinguishable from a basal-cell carcinoma. It is of interest to note that a similar profusion of cellular structure may be observed in the so-called mixed salivary tumours, better described by Willis (1948) as 'pleomorphic salivary adenomas'.

The pituitary adamantinoma possesses a similar histological appearance to that occurring in the mouth, which is not surprising in view of the origin of the anterior part of the pituitary gland from Rathke's pouch, which is itself derived from the stomatodæum. The so-called adamantinoma of the tibia is undoubtedly a basal-cell carcinoma which has invaded bone and should not be considered in the same category.

CLINICAL FEATURES

The clinical behaviour of an adamantinoma bears a close resemblance to that observed in a typical basal-cell carcinoma in that growth is slow, with

local progressive invasion of the surrounding tissue, and a pronounced tendency towards recurrence following inadequate removal. It is, however, uncommon for the neoplasm to extend beyond the periosteum unless previous operative interference has taken place. Enlargement of the regional lymph-nodes does not occur, and metastasis is rare.

TREATMENT

Although the clinical and radiological appearances may be strongly suggestive of adamantinoma, biopsy is essential if errors are to be avoided. This may be carried out by means of drill biopsy from the exterior, or by an intra-oral approach. The latter method, which provides a more generous specimen,

FIG. 302.—Pre-operative appearance.

Growth of the neoplasm is painless, unless infection from the mouth, or more rarely the exterior, has supervened. Robinson (1937), in a review of a series of 379 cases, found that 45·7 per cent occurred in males and 54·3 per cent in females; the average age at the time of discovery was 30·1 years, with an average age of duration of 8·5 years; the majority of cases (83·7 per cent) occurred in the mandible; no less than 30 per cent of all cases had recurred following local removal, but only 4·5 per cent metastasized or showed histological evidence of malignancy.

RADIOLOGICAL APPEARANCES

The typical case reveals a multilocular, radiolucent lesion which is most commonly observed at the angle of the mandible where expansion and thinning of the outer and inner cortex of the bone takes place. This picture may be seen in many other neoplasms, and is frequently mimicked by large dental or dentigerous cysts where bony septa act as re-inforcing struts and thus give rise to a pseudo-multilocular appearance. On the other hand a true adamantinoma can present radiologically as a unilocular area of radiolucency, and it will thus be apparent that the disparity in the radiographic appearances precludes the placing of too great a degree of reliance upon the radiological interpretation of the condition for diagnostic purposes.

has the disadvantage that the wound may heal with difficulty, particularly if the incision is placed over a cystic cavity, when the subsequent sinus will heal slowly or possibly fail to heal at all, thus mitigating against the successful performance of an immediate bone-graft following removal of the neoplasm.

The high rate of recurrence in the series quoted by Robinson provided abundant proof of the undesirability of attempts to cure the condition by local curettage from an intra-oral route. The essentially multilocular nature of the neoplasm spreading widely throughout the cancellous spaces of the bone must inevitably preclude any hope of success by this method. Where the lesion appears to be in an early stage and there is unequivocal radiological evidence that the condition is confined to the upper portion of the alveolar bone, there is some justification for a resection of this portion only, leaving the uninvolved basal bone or cortex at the lower border. This technique must, however, always be performed from an external approach otherwise it will be impossible to be certain that the neoplasm has been entirely excised, particularly when it extends up the ascending ramus towards the neck of the condyle. Very few cases are amenable to treatment by this method, and a careful clinical judgement based upon some degree of experience is necessary.

The consensus of opinion in this country is that radical resection of the affected area is the method

of choice. McWhirter (1952) has attempted to treat some cases by means of radiotherapy, but the great majority of adamantinomata, unlike their counterparts in the skin, must be regarded as radio-resistant.

FIG. 303.—Tantalum and acrylic implant.

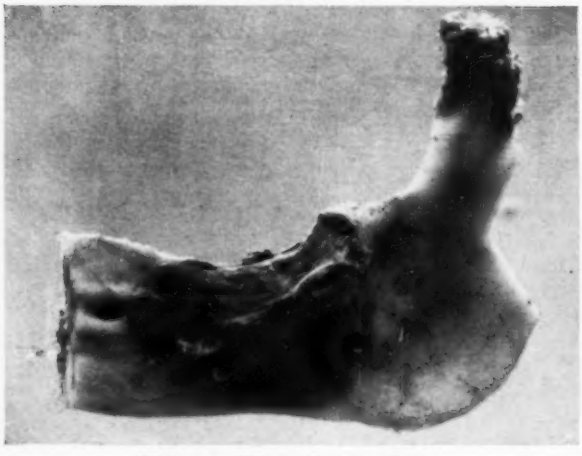

FIG. 304.—The excised specimen.

Following the removal of the affected portion of bone, the continuity of the mandible should be restored by an autogenous bone-graft, preferably from the iliac crest. If the wound has become compounded into the mouth, the immediate replacement of bone is inadvisable owing to the risk of subsequent infection and sequestration. The danger of perforating the oral mucosa may be avoided by careful attention to technique and the extraction of adjacent teeth at least one month prior to resection with careful closure of the mucoperiosteum to accelerate healing. Should exposure to the mouth have occurred, at least six weeks should be allowed to elapse before proceeding with the bone-graft.

When teeth are present, the control of the fragment or fragments pending the insertion of a graft presents no difficulty, since cast metal cap splints may be employed. In the edentulous case, however, this may be a considerable problem since the retention of pins and extraskeletal fixation is often inadequate for both the post-resection period and the interval of approximately five to six weeks which must elapse before the graft is sufficiently firm to dispense with fixation. The use of stainless steel rods or Steinmann pins embedded into the bone-ends, and acrylic space-retainers have been employed in the past in order to prevent deviation of the chin towards the resected side, with subsequent interference in contour due to fibrous contraction. Castigliano and Gross (1951) have described the immediate insertion of a vitallium half-mandible following resection for malignancy with successful functional retention of this allelograft for eighteen months subsequently. Vitallium requires the possession of special laboratory facilities so that it may be cast at high temperatures and the alloy is difficult to work and polish owing to its extreme hardness. In the case about to be described, it was decided to attempt to overcome these difficulties by using tantalum sheet and acrylic, neither of which material requires anything other than simple dental laboratory facilities for its working and processing.

CASE HISTORY

H. W., a male aged 63 years, consulted his doctor because of a slowly enlarging painless swelling at the left angle of the lower jaw which he had first noticed about a year previously. The only inconvenience suffered by the patient was in respect of his lower denture, which he considered did not fit as well as previously.

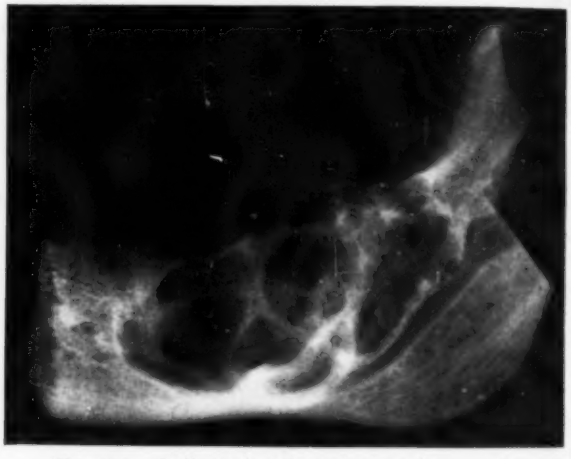

FIG. 305.—Radiograph of the excised specimen. Note the multilocular appearance.

CONDITION ON ADMISSION.—Externally the left side of the face in the region of the angle of the mandible was noticed to be slightly enlarged by a firm, non-tender swelling which was oval in shape and measured 4 cm. × 3 cm. The overlying skin was freely mobile, and there was no enlargement of the regional lymph-glands (*Fig.* 302).

Intra-orally there was a pronounced enlargement of the edentulous mandible extending from the region of the mental foramen to the retromolar fossa on the left side. The overlying mucosa appeared normal, and moved freely over the underlying swelling which had obscured the buccal sulcus. On deep palpation a sense of fluctuation could be elicited, and the impression was gained that considerable thinning of the underlying bone had taken place. The heel of the lower denture had caused some degree of ulceration of the tissues, although it had obviously been filed down considerably.

Radiographically it was observed that a multilocular radiolucent area of bone destruction was present at the left angle of the mandible, extending up the ramus towards the region of the sigmoid notch, but not involving the neck of the condyle. The entire cross-section of the mandible in this region was involved, the expansion of

the bone measuring approximately 3 cm. Considerable downward displacement of the inferior dental canal was noted.

A provisional diagnosis of adamantinoma was made, and a biopsy performed from an intra-oral approach. Despite careful suture, the small incision in the mucous membrane failed to heal, a persistent sinus developing. The histological report confirmed the presence of an adamantinoma.

PRE-OPERATIVE PROCEDURE.—It was appreciated that immediate restoration with a bone-graft was not possible in view of the intra-oral sinus, and that fixation following resection to avoid deviation of the remainder of the mandible would be extremely difficult. It was therefore decided to insert a space-retainer, and it was felt that this should be constructed so as to restore the function and appearance of the mandible as far as possible, and that should success be achieved the prosthesis should be left in situ indefinitely.

By careful clinical and radiographical measurement a half-mandible of 'girder-like' construction was made in the dental laboratory from sheet tantalum of 2-mm. gauge thickness. The trough between the sides of the 'girder' was filled in with clear methyl methacrylate resin in order to avoid any dead space, but the acrylic was not extended beyond 2 cm. from either extremity to allow for the attachment of the prosthesis to the bone by tantalum wires passed through holes drilled in the bone-ends (*Fig.* 303). A decision was taken to preserve the condyle and condylar neck as these areas were not involved, and an obviously superior function would result from their retention.

OPERATIVE TECHNIQUE.—(Anæsthetic: Pentothal, nitrous oxide and oxygen with intravenous pethidine—Dr. G. E. Ennis.) A curved submandibular incision, placed within a natural skin crease, was made extending from a point 2 cm. below the lobe of the left ear forwards to a point below the canine region on the same side. The platysma and deep fascia were divided and the periosteum and attached muscles freed from the body and ramus. The neck of the condyle was drilled with a fissure bur attached to a dental handpiece and tantalum wires passed *prior* to division of the condylar neck so as to ensure adequate control of the bone. A similar procedure was carried out immediately anterior to the mental foramen, the intervening bone resected in one piece (*Figs.* 304, 305) and the prosthesis securely wired in place (*Fig.* 306). The wound was then carefully closed, using interrupted catgut sutures for the fascia and platysma, and black silk sutures for approximation of the skin edges. No drainage was considered necessary or desirable. Finally the margins of the intra-oral sinus were excised and sutured.

POST-OPERATIVE COURSE.—This was uneventful apart from some post-operative retention of urine as a result of pre-existing prostatic hypertrophy. No fixation of

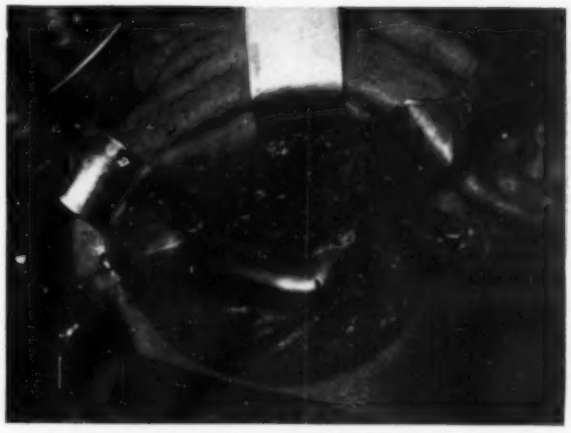

FIG. 306.—Appearance at operation following resection and insertion of the implant.

FIG. 307.—Post-operative appearance one year later.

the jaws was attempted apart from firm bandaging, which was removed after a week, when it was found that a full range of mandibular movement existed, and that the operation wounds had healed by first intention. At no time was there any evidence of infection or of intolerance of the prosthesis by the tissues. Penicillin, 500,000 units of aqueous solution b.d., together with streptomycin 0·5 g. b.d., were administered parenterally for five days as a prophylactic measure. Four weeks post-operatively the junction between the prosthesis and the bone was quite firm, and a fortnight later it was possible to re-insert the patient's original dentures ; they occluded very satisfactorily under the circumstances, but to avoid any trauma to the mucosa, the lower denture was subsequently relined.

SUBSEQUENT PROGRESS.—The patient has been followed up at intervals both clinically and radiologically for a period of two years. After three months a new set of dentures was constructed in order to provide the optimum result, and the patient has continued to enjoy a full range of mandibular movement. The appearance and restoration of contour are most satisfactory, and there is no evidence of tissue intolerance or bone resorption at the junction of the body of the mandible, condylar neck, and the prosthesis (*Fig.* 307). It is proposed to leave the tantalum and acrylic allelograft in situ until such time as there may be any indication for its removal, in which eventuality there would be no reason to prevent the insertion of an orthodox bone-graft.

SUMMARY

A brief review is given of the aetiology and pathogenesis of adamantinoma, and reference made to the essential histological and clinical features of the condition. The radiological appearances and treatment are discussed and a case presented which was treated by resection and immediate replacement by a prefabricated allelograft of tantalum and acrylic resin. The condition after two years is described.

The authors are grateful to Dr. H. Richards, Consultant Pathologist to the Winchester Group of Hospitals, for the histological examination of this case. They would also like to express their appreciation of the assistance rendered by Mr. E. Yates, Senior Dental Technician (Surgical), who constructed the prosthesis, and Mr. E. Ferrill, of the Department of Medical Photography, who was responsible for the photographs.

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THE PATHOLOGY AND TREATMENT OF VENOUS ULCERS OF THE LEG*

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INTRODUCTION

In October, 1950, it became part of the author's duties to run two clinics, a Varicose Vein Clinic and a so-called Varicose Ulcer Clinic. These clinics were held once a week on different days. During the ensuing three months certain facts became very clear. First, was the magnitude of the problem. A severely pruned appointment system soon had to be instituted otherwise both clinics would have been swamped. Second, was that in the two clinics one appeared to be seeing two different conditions with somewhat different pathology. In the Varicose Vein Clinic large numbers of patients were seen with gross incompetent varicose veins of great and small saphenous systems, yet the majority had healthy skin around the ankles. On the other hand in the Ulcer Clinic well over half the so-called varicose ulcers seen showed no incompetence of the superficial venous system, and in many of them no varicose or dilated veins of any sort could be seen. Although this anomaly was first pointed out by John Gay in 1867 (1868), the explanation of it we owe mainly to John Homans (1916 ; 1917), who first clearly established the relationship between previous deep vein thrombosis and ulcer of the leg. However, after excluding all cases that gave a definite previous history of deep thrombosis or white leg there was still left a residuum of cases with ulcer of the ankle, of venous origin apparently, without a history of previous deep thrombosis and without incompetent superficial veins of the great saphenous system.

As this large number with ulcers of the leg were being seen concentrated in one clinic, the opportunity for a detailed investigation of this group of patients presented itself. It is probable that this clinic represents a fair cross-section of the ulcer population of a large city, as cases were referred to it not only from all other departments of the hospital, but also directly from the general practitioners.

The general plan of the investigation was as follows :—

1. To make a clinical study of the various types of ulcers seen ; to observe their natural history and response to various forms of treatment, both conservative and surgical.

* This paper is based on a thesis for the degree of M.S. (Lond.), which was accepted in September, 1953.

2. To attempt to make a clinical classification of patients with ulcers of venous origin according to the site of venous incompetence.

3. To investigate a representative cross-section of each clinical group by venography, the measurement of venous pressures, and by the findings at operation.

4. To make an anatomical study of the venous system of the human leg, with special reference to (*a*) the anatomical variations of the femoral and popliteal veins, and (*b*) the sites of the main communicating veins between superficial and deep systems, particularly in the lower leg in the ulcer-bearing area, and (*c*) to study the arterial supply of the subcutaneous tissues of this area.

THE PROBLEM OF CLINIC ORGANIZATION AND ROUTINE TREATMENT

At the ulcer clinic a limited appointment system was instituted. Each new patient was seen by the author and a doctor from the department of Physical Medicine together. At this first interview a full history was taken and examination made. Then the decision as to whether the patient was to be put down to come in for surgery, or was to have conservative treatment only was taken. In either case, the patient was then referred to her individual masseuse, who became responsible for educating her in the management of her leg, either as a conservative long-term policy or until the patient was admitted for surgery.

The routine conservative management of these ulcers was very simple. The basic routine dressing is shown in the picture comprising *Fig.* 308. The most important points about this routine are: (1) The education of the patients in the details of applying the elastic bandage; (2) The encouragement of movement and exercise of the leg and calf—the patients were not put off work or limited in their activities in any way; (3) The avoidance of all irritating applications to the ulcer site. Cr. Zinci and Ol. Arachis are the only two applications in routine use. The further details of this ambulant treatment have been reported by Curwen and Scott (1952).

Although this treatment is of immense value and grateful patients are numbered in hundreds, it suffers from certain inherent disadvantages. First, it necessitates unremitting care in the application and care of bandages and stockings for the rest of the patient's life. If this vigilance is relaxed there is every likelihood that the ulcer will soon recur. Secondly, the pads and bandages, and even the stout stockings, are bulky and sometimes uncomfortable to wear, particularly in hot weather, and many of the patients, particularly the younger ones, are intolerant of them. Thirdly, some ulcers, particularly post-thrombotic ones, repeatedly escape from control, even on full routine treatment, and a small number are never completely healed (Cokkinis, 1933).

Thus we have reserved this as the sole method of treatment for those cases in the upper age group, and for those who do not wish for operative treatment. We have been reluctant to operate on any patient over the 50–60 age group. This has in general been in accordance with the patient's wishes, for we have found that patients over the age of 50 have not been willing to undergo any form of operative treatment if effective ambulant conservative treatment can be offered. On the other hand most patients below the age of 50 have been eager for operative treatment, and most of the investigations and operations have been carried out on these younger patients. All patients chosen for operation undergo a preliminary period of this ambulant conservative treatment, with the result that most ulcers are healed, or nearly so, by the time the patient arrives in the hospital. This effects a great saving of time in the hospital, and of course greatly reduces the risks of infection when any operative procedure in the ulcer area itself, or elsewhere in the leg, is contemplated.

THE CLINICAL MATERIAL AND THE CLINICAL CLASSIFICATION OF ULCERS

This study is based on 234 new cases of leg ulcer seen at the Ulcer Clinic in 1951 and 1952. Of these, 75 were male and 159 were female. Of these cases, 52 were not considered to be of venous origin (traumatic, infective, erythrocyanotic, arteriosclerotic, syphilitic, etc.) and were excluded from this study. The remaining 182 cases were classifiable into three groups :—

Group 1 :	Ulcers with obvious incompetence of superficial veins. No history of thrombosis	97
Group 2 :	Ulcers with a definite preceding history of deep femoral thrombosis or white leg	38
Group 3 :	Ulcers with no demonstrably incompetent superficial veins and with no definite preceding history of thrombosis	47
		182

In addition, in the 1952 group of cases were 8 cases of ulcer which had recurred after an efficient Trendelenburg operation.

The clinical criteria on which the grouping is based in this paper must be carefully defined.

Group 1.—Most of these patients had a palpable cough impulse in the great saphenous vein and varices below the knee, with an ulcer usually above and behind the internal malleolus. A small number had incompetence of the small saphenous vein only, as shown by its dilatation and tortuosity, with ulceration or eczema behind and below either the external malleolus or both malleoli.

Group 2.—These were patients who gave a definite history of white leg or femoral thrombosis. The usual history was that the whole leg from ankle to groin became swollen and remained so for several weeks after parturition or a severe illness. The patient was confined to bed for several weeks and the limb continued to swell after walking on it for some time afterwards. Such an occurrence is not easily forgotten by patients and thus the history is usually very definite. Over two-thirds of these patients had no varicose veins visible on the surface of the limb at all.

Group 3.—These patients had no incompetent veins judged by the criteria for group 1. Some of them had superficial veins visible in the lower third of the leg, but they did not appear to be connected to an obviously incompetent great or small saphenous system. They did not give a history of deep thrombosis, as judged by group 2 criteria. However, it is very probable that many of these patients had had thrombosis confined to the calf on some previous

A

B

C

D

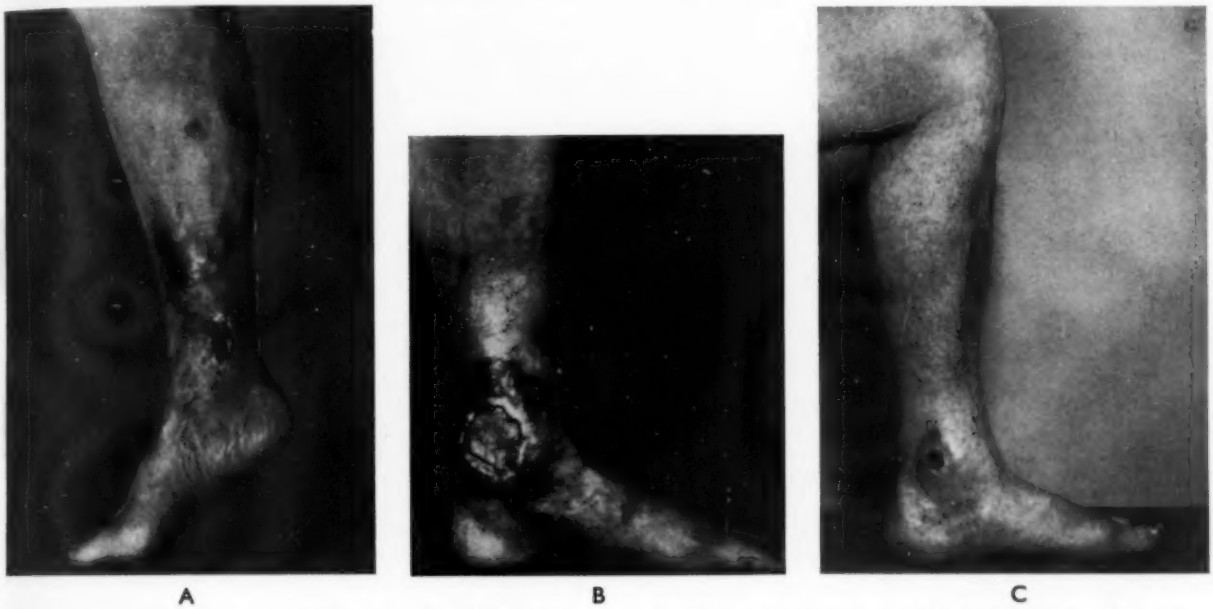
E

F

G

FIG. 308.—A, Venous ulcer. B, Zinc cream to the ulcer itself. Arachis oil (olive oil) to the surrounding skin. C, Piece of dry gauze to cover ulcer and surrounding skin. D, Felt pad applied, cut to cover ulcer, surrounding skin and extending upwards to give pressure to region of ankle perforating veins. Crêpe bandage applied, to keep pad in place and form the 'basis' for the heavy webbing bandage which should not be applied on the unprotected skin. F, G, Application of heavy elastic webbing bandage—showing technique of getting firm elastic pressure below and behind the malleoli.

occasion. It was found that even on close questioning it was usually impossible to be sure whether or not this was so. The transient swelling and pain of calf thrombosis are soon forgotten by the average patient. Some of these patients undoubtedly had had thrombosis confined to the calf or lower leg and gave a very suggestive history. A few had clinical signs of deep thrombosis at the time of examination (calf tenderness). But in none of them had the thrombosis been serious enough to have spread to the popliteal vein or to give rise to the typical clinical history elicited from group 2 cases. Moreover, none of these cases suffered from the severe chronic œdema and heaviness and aching of the limb which was so typical of group 2 cases.



A B C

FIG. 309.—A, Mrs. G. H. This leg belongs to a lady of 51. The ulcer had been present on and off for 9 years, with no history of deep thrombosis. She has an easily palpable cough impulse in the prominent veins which can be seen. Clinical group 1.
B, Miss S. B. This leg belongs to a girl of 28. The ulcer had been present for 5 years and had recurred after a skin-graft. She had a white leg following pneumonia 2 years before the ulcer broke out. There are no superficial veins visible or palpable. The leg swells and aches towards evening. Clinical group 2.
C, Mr. F. B. This leg belongs to a fit young man of 33. He has had this ulcer on and off for 11 years. There is no history of deep thrombosis. There are no dilated veins of the great or small saphenous system visible. High-saphenous ligation and skin-grafting had both been done without success. The limb did not swell or ache. Clinical group 3.

The three photographs comprising *Fig.* 309 show the essential features of the three groups.

In the Varicose Vein Clinic we began to recognize the warning signs in the lower leg, the ulcer precursor state. The commonest precursor lesion is a spray of fine dilated venules which spreads over the inner surface of the ankle, behind the malleolus, and flares out to be lost in the thick skin of the heel pad. This is a typical clinical sign of a venous ulcer—and we have called it the 'ANKLE FLARE'. In women with erythrocyanoid limbs or with much subcutaneous fat this early venular dilatation is not seen well, but it gives rise instead to a localized firm plaque in the subcutaneous tissues of the region which is highly typical. We have shown at operation that this firm plaque consists of an area of œdematous and fibrotic fat, with areas of fat necrosis, interlaced with dilated veins (*Fig.* 318 A). When the skin over this breaks down a blue necrotic looking ulcer which is very painful and slow to heal results (*Fig.* 309 B). Of course, all gradations between these two types of early clinical pathology exist.

I should like to end this section on the clinical observations by quoting part of a letter to the *British Medical Journal* by Hanschell (1949): "The great majority of patients with varicose veins, at all ages, have and have had no leg ulcers, while the great majority of patients with leg ulcers, at all ages, have and have had no varicose veins; yet in its clinical features, under all conditions there is no discernible difference between ulcer with and ulcer without varicose veins." (*Fig.* 309.)

This observation was first stressed by an English author, John Gay, in 1867, who made the first scientific investigation into the causes of ulcer of the leg in this country, and who first suggested the term 'venous ulcer' for them.

ANATOMY AND PHYSIOLOGY OF THE VENOUS SYSTEM OF THE LEG

The Deep Veins.—In order to study the deep veins 26 dissections of the femoral and popliteal veins in post-mortem bodies were made. The whole of the deep system was removed, dissected, and pinned out on a board; a drawing of this was then made. Then the veins were opened and another drawing made of the number and location of the valves.

a. Gross Anatomy.—*Fig.* 310 shows the variation in anatomy of the femoral and popliteal veins as discovered at these 26 dissections.

It is at once evident from a study of these wide variations what different effects ligation or thrombosis of the deep veins might have from patient to patient, according to the availability of collaterals. Another important point is the presence of a very constant

anastomosis between the femoral and profunda systems which occurs at the region of the adductor canal. This means that ligation of the femoral vein in Hunter's canal, distal to the profunda origin, would leave a good deep venous collateral pathway.

b. Number and Position of Valves.—The average number of valves found between inguinal ligament and popliteal fossa was five. However, much the most striking fact was the variation in normal valvular equipment, any number from two only, up to nine being found in different cases in the same stretch of vein. The most constant valve is that which occurs just distal to the entry of the profunda vein. There is another at about the mid-point of the thigh just above the adductor canal usually, and another in the popliteal vein. From the point of view of interpreting venograms of these veins it is important to remember this great variation in number of valves. If one or two valves can be demonstrated in any stretch of vein, it can be confidently looked upon as normal.

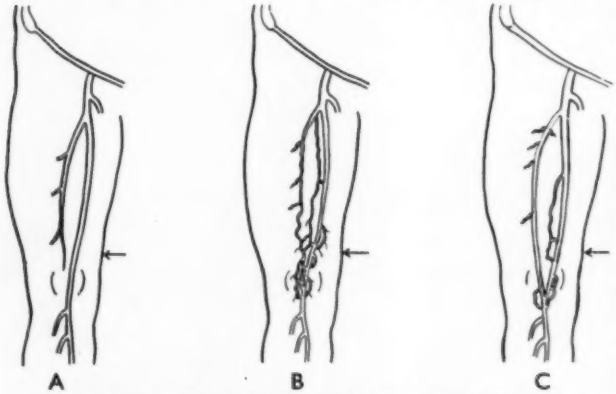


FIG. 310.—The pattern of anatomical variation in the main deep veins of the thigh (26 dissections). (The arrow indicates the position of the adductor canal.)

A, A group (approximately 16 per cent of those dissected) in which there were very few venous collaterals of dissectable size. The situation as depicted in most anatomy text-books.

B, A group (approximately 72 per cent of those dissected) in which there was considerable reduplication of the main channels, with a rich network of large collaterals between the profunda and femoral systems—at the level of the adductor canal.

C, A group (approximately 12 per cent of those dissected) in which the profunda was a vessel equal in size to the femoral, draining the popliteal vein and its mass of venæ comites by one or more large communications. In this type of case ligature of the femoral vein in Hunter's canal would have practically no effect on the efficiency of venous return from the limb.

This work was in substantial agreement with the work of Eger and Casper (1943), Powell and Lynn (1951), and Bazmajian (1952).

The Anatomy of the Venous Drainage of the Muscles of the Leg.—*Fig.* 311 shows the anatomy of the venous drainage of the calf, and *Fig.* 312 shows the same thing in diagrammatic form.

First notice that the venous drainage of the soleus and gastrocnemius muscles which constitute by far the greatest bulk of the calf, is very different.

Soleus.—The soleus muscle has a series of large venous sinuses within it which are devoid of valves. These venous sinuses differ from subject to subject in their size and degree of development, and they are of some importance as it is in them that calf thrombosis starts. They drain by a series of short but lax veins into the posterior tibial and peroneal veins as shown. The venous drainage of the lower half of the soleus is particularly interesting and significant when we come to consider the genesis of post-thrombotic ulcers. Firstly it will be observed in *Fig.* 311 *that nearly the whole venous drainage of the lower half of the calf goes into the posterior tibial vein.* The peroneal vein is quite small in the lower third of the leg and runs deep to the flexor hallucis longus origin from the fibula, quite close up against the interosseous membrane. In this region it receives one fairly constant large lateral perforating vein. This vein as it winds around the fibula receives a branch from the soleus. This represents its only contribution from soleus in this region. In the upper half of the leg the peroneal vein emerges from under the flexor hallucis belly to lie in the posterior compartment, and here it receives several large lax veins from the lateral aspect of soleus, which rapidly coverted into quite a large vein before it unites with the posterior tibial to form the popliteal. Now turning to the posterior tibial veins in the lower third of the leg it will be observed that *at the exact point where these veins receive the two lowest muscular veins from soleus they also receive two large perforating veins*, which perforate the deep fascia of the leg and drain the subcutaneous tissues of the internal malleolar region (the ulcer and induration area). This arrangement is also shown in the photograph of the dissection in *Fig.* 315 B, C. This anatomical arrangement is the key to appreciating two things : (1) That there is a direct anatomical pathway for the spread of thrombus from calf sinuses to posterior tibial veins and then either outwards in the perforators and/or upwards in the posterior tibial veins. (2) The reason why the site of election for the cutaneous sequelæ of deep thrombosis is so often the *inner* side of the leg in the malleolar region and not the outer side.

Gastrocnemius.—Each belly of gastrocnemius is drained by a single large vein which enters the popliteal vein in the lower part of the popliteal fossa. These veins are often seen on venograms of the region and are easily picked out. They are accompanied by an artery and a nerve. When the valves of the popliteal and femoral veins are destroyed by the process of deep thrombosis and recanalization, these veins are subjected to an increased venous pressure from above and sometimes dilate and become tortuous and varicose, constituting one type of true deep varicose veins.

The Anatomy of the Superficial Veins and the Communicating Veins.—The fact that ulcers of venous origin, whatever the aetiology—varicose or post-thrombotic—occur so constantly in one particular area, namely just above and behind the internal malleolus, was the reason why a detailed investigation of the immediate venous drainage of this area and its arterial supply was undertaken. It seemed to the author that there must be some anatomical arrangement of the venous drainage of this spot which would account for the peculiar constancy of the occurrence of ulcers here.

The anatomical description which follows here is based on dissections of the subcutaneous tissues of the region in 18 fresh post-mortem legs and in 3 amputated legs. The amputated legs were prepared in the following way: A vein in the foot was

cannulated and the limb perfused through the vein with formol saline for a short time ; then the venous system was injected with black neoprene. The limb was then kept in the refrigerator until ready for dissection. By this method the veins stood out in black and could easily be dissected and photographed (*Fig.* 315).

Most of the facts about to be described were first discovered by Verneuil (1855 a, b) and by Gay, and are described in Gay's Lettsomian Lectures in 1867.

FIG. 311.—Anatomy of the venous drainage of the soleus. The soleus and tendo Achillis have been split vertically and folded outward to reveal the contents of the plane between the deep and superficial muscles of the calf. (For full description *see* text.)

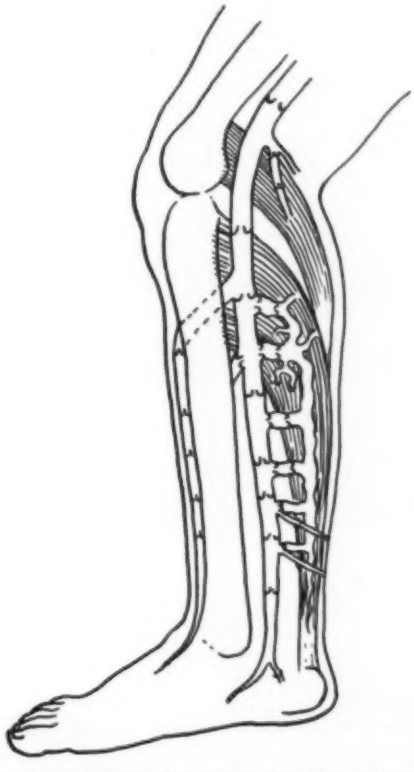


FIG. 312.—Diagram of the venous drainage of the soleus and gastrocnemius muscles of the calf – showing the essential differences. Also showing (diagrammatically) the origin of the upper and middle ankle-perforating veins, and the venous sinuses within soleus.

But they appear to have been forgotten and find no mention in most modern anatomy books and textbooks.

The superficial veins of the inner side of the leg are shown diagrammatically in *Fig.* 313. The great saphenous vein is the only superficial vein of the leg which pursues a constant course and is very constant in position. Its branches are subject to great variation but their general pattern is as shown.

The great saphenous vein itself is a strong muscular structure ; its branches are very much thinner walled and tend to dilate and become tortuous and varicose in a way in which the saphenous vein itself never does. (This fact was first noticed and described by Briquet, 1824.) It gives off a number of large branches at the level of the knee. There are generally three groups : (1) A group which goes posteriorly to join and occasionally replace the small saphenous system. (2) An anterior vein, which winds over the anterior surface of the tibia below the knee. (3) A large constant posterior arch vein which goes down the posterior aspect of the inner side of the calf to anastomose with a series of small venous arches which arise from three perforating veins which occupy the position shown (*see Fig.* 313). These perforating veins collect the venous drainage of this area of the leg (known as the gaiter area), perforate the deep fascia in the position shown, and empty directly into the posterior tibial veins. They are short and quite large vessels. There is some variation in their relative size from case to case. The upper one of the three is the most constant in its situation, nearly half-way up the leg, just posterior to the bony margin of the tibia. It constantly communicates with the saphenous vein by a small branch as shown. The upper, middle, and lower perforating veins vary a good deal in their relative size from case to case. However, the middle perforator is fairly constant in position, usually about four finger-breadths above the internal malleolus. The lower perforator is just behind the internal malleolus and is often very small. *These veins are each provided with one or more valves which permit the flow of blood inwards from the subcutaneous tissues to the posterior tibial veins, but not in the reverse direction.*

It can thus be appreciated that in the *erect position* the essential venous drainage of this ulcer-bearing area is directly into the deep veins via these direct ankle-perforating veins, and not via the saphenous system at all (*see Fig.* 313). On the other hand the effects of venous incompetence in the superficial system can readily reach this area via the posterior venous arch vein, arising from the saphenous

at knee level, labelled 3 in *Fig.* 313. From the thin-walled venous arch connecting the perforating veins to each other and from the perforators themselves numerous small delicate vessels drain the subcutaneous tissues of the region.

The saphenous vein itself runs from just below the knee to ankle with no major branches until below the ankle it rapidly breaks up into a series of branches draining the subcutaneous tissues of the foot and freely anastomosing with branches of the anterior tibial and posterior tibial veins in the foot.

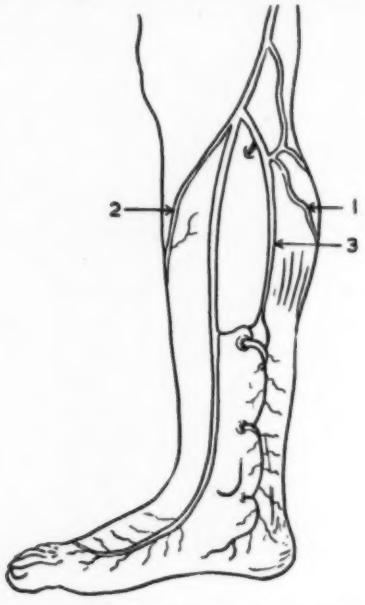


FIG. 313.—Venous drainage of the inner aspect of the leg and foot. (For description *see* text.)

The venous arrangement of the outer side of the limb is somewhat different and not so constant anatomically. The usual arrangement is shown in *Fig.* 314.

There is one large constant perforating vein the origin of which has already been referred to, in the position shown on the diagram. The course of the small saphenous vein is essentially from the popliteal fossa, where it enters the popliteal vein, down the middle of the posterior aspect of the calf. It may perforate the deep fascia at any point from the lower part of the popliteal fossa to about half-way down the calf. Soon after it is joined by the lateral perforating vein in the lower third of the calf it veers towards the external malleolus and breaks up rapidly into many small branches in the hollow between the external malleolus and tendo Achillis. It often sends a branch or branches across the back of the tendo Achillis to communicate with the lower part of the venous arch connecting the lower two *medial* perforating veins. Thus incompetence of this vein is liable to result in dilatation of the small thin-walled branches in the hollow behind the two malleoli, particularly the lateral malleolus, and ulcers and eczema resulting from this are commonly found in this situation. The arrangement whereby the small saphenous vein is almost entirely replaced by a large branch of the great saphenous arising at knee level is not uncommon.

Now an interesting and important anatomical point must be described. A study of photographs of detailed dissections of the upper and middle perforating veins on the inner side of the leg should be made (*Fig.* 315). These perforating veins, the upper and middle, enter the posterior tibial venæ comites at the same point where one of the large veins draining the soleus enters. In fact, as already pointed out, there is a direct anatomical pathway for thrombus spreading down this vein from soleus to enter not only the posterior tibial vein but also the perforating vein. The organization and recanalization of such thrombus will involve destruction of its valves and production of an incompetent perforating vein in this situation. This actual occurrence has been seen by us at post-mortem dissection, and we believe that this is probably the usual mechanism whereby the valves of the perforating veins may be destroyed.

FIG. 314.—Venous drainage of outer aspect of leg and foot. (Note the position of the constant large external ankle perforator.)

This anatomical arrangement was noted and commented upon by Gay (1868) also. He made the comment that at these points there appeared to be an alternative venous pathway direct from the soleus muscle to the superficial veins which could be used if the deep veins were blocked.

There are numerous other small, inconstant, indirect, perforating veins over the muscle bellies in the upper part of the leg, but no others are so large, so constant in situation, or so significantly placed with regard to ulcers as those just described. The two constant communicating veins in the lower third of the thigh and just below the knee have been adequately described elsewhere by Boyd (1948), Warwick (1931), Kinmonth and Robertson (1949), and Linton (1947).

The Effects of Incompetence of the Perforating Veins.—The normal flow of blood in the veins in the leg is from superficial to deep; all the valves of the leg veins are arranged to this end. The mechanism of the calf pump in returning blood from

Posterior arch vein (see Fig. 313)
This forceps holds a thread round the posterior tibial artery and venæ comites
This and the top forceps are holding the deep fascia of the leg which has been dissected up as a separate layer

A

B

C

FIG. 315.—Dissections of an amputated leg, prepared by injecting black neoprene into the veins, to show the detailed anatomy of the upper and middle internal ankle-perforating veins.

A, Shows the inner aspect of the lower leg dissected from behind. The upper two perforating veins are shown, labelled (1) and (2). The fine venous arches connecting the perforators in the subcutaneous tissues is seen.

B, Shows a close-up of the region of the upper perforator, dissected further to show its entry through the deep fascia into the posterior tibial venæ comites.

C, Shows a close-up of the region of the middle perforator. The artery forceps is holding up the deep fascia, and the veins are seen perforating it to enter the posterior tibial venæ comites, and notice particularly how the vein from soleus joins it at the same point. This arrangement is also evident in the upper perforator in B. The small perforating artery is well seen.

the leg in the erect position is well known. The deep fascia of the leg, particularly in the lower third, forms a firm investing layer to the large calf muscles. When these contract within this firm sheath, venous blood is squeezed upwards with considerable force. It is prevented from leaking outwards, out of the pump, via the perforating veins, by their valves. Barcroft and Dornhorst (1948) have shown that this calf pump can overcome a resistance greater than 100 mm. of Hg.

Moreover, from the work of Wells, Youmans, and Miller (1938) we have good evidence that the pressure within the calf on contraction is greatest in the lower third, where the perforating veins go in. These investigators measured the rise in intramuscular pressure on contraction by a method involving placing a needle in muscles at various levels. They found a great difference in the pressure in muscles which were *not* invested by a tight fascia, such as the rectus femoris, and those that were, such as the soleus. The maximal rise of intramuscular pressure on contraction of rectus femoris was 18 mm. Hg. In the lower third of the soleus the rise of pressure on contraction was 90 mm. Hg, and the contraction pressure fell gradually to between 30 and 40 mm. Hg as the needle was put in higher and higher in the calf. Thus there is unequivocal evidence from this work that on contraction of the calf there is a considerable rise of pressure within it, particularly in the lower third.

The probable effect of incompetence of the valve of a perforating vein is shown diagrammatically in *Fig.* 316.

Via these short wide veins, if their valve was rendered incompetent, this great rise of pressure on every calf contraction could be transmitted straight out to the delicate venous mesh with which they are connected. The result of this would be a gradual dilatation of all the small venules in this area, a condition which, as has already been noted, we have seen frequently as a pre-ulcer phenomenon.

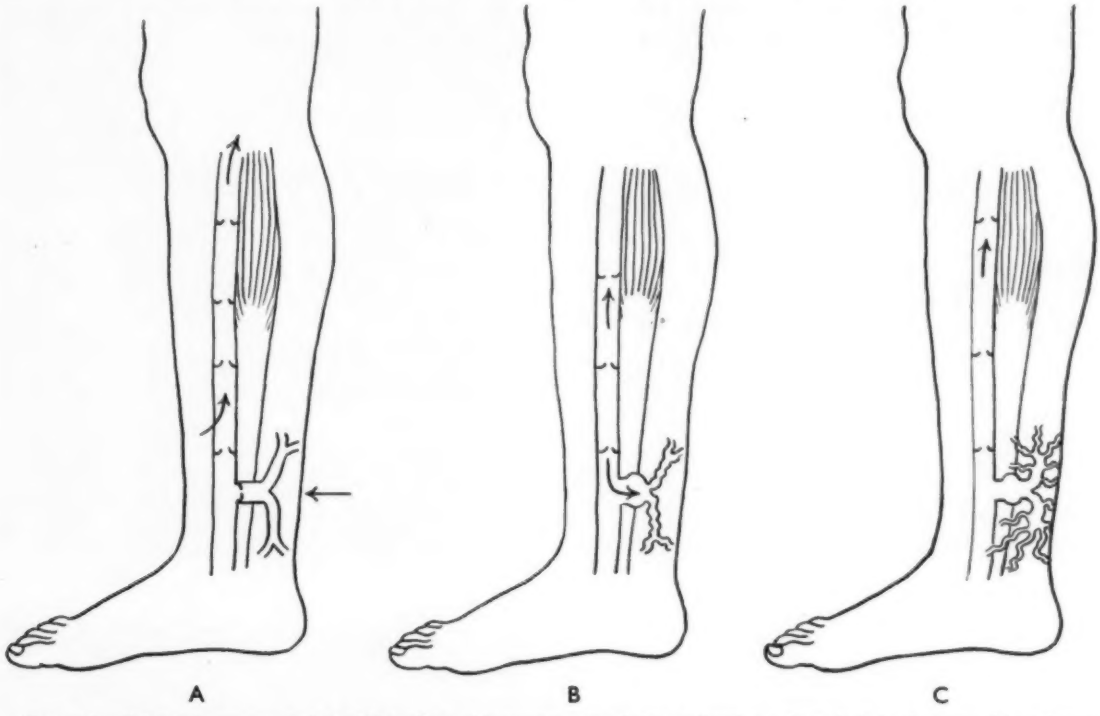


FIG. 316.—Schematic representation of the effect of incompetence of the perforating vein, a leak in the powerful calf pump.
A, Normal arrangement of valves. The arrows indicate direction of blood-flow.
B, Effect of destruction or incompetence of the valve at the point of entry of the perforator into the deep vein. The arrows indicate the direction of flow on contraction of the calf.
C, Final result. Dilatation of the stump of the perforator, and dilatation and tortuosity of all the veins in the subcutaneous tissues which drain into it.

Summary.—*In the erect position the essential venous drainage of the ulcer-bearing area is into the deep veins, mainly but not entirely via the three large perforating veins on the inner side and the one large perforator on the outer side of the leg. The saphenous system has little place in the venous drainage in the erect position.*

This anatomy is in entire accordance with all clinical experience of chronic lesions of this region, as it has become increasingly recognized that the most chronic and resistent ulcers are more often associated with pathology of the deep veins than of the superficial. However, it has been shown that the effects of venous incompetence of the saphenous system can also reach this same area very easily via the large posterior arch vein arising from the saphenous at knee level. This vein was seen by Leonardo da Vinci and clearly shown on one of his anatomical drawings. The hypothesis is advanced that an ulcer is the end-result of a local rise in venous pressure over this area leading to local œdema and ischæmia maximal over the skin area drained by the ankle perforating veins.

On the basis of the clinical experience with ulcers already referred to earlier, it is believed that it is

possible to diagnose fairly accurately which group of veins is primarily responsible for the occurrence of ulceration.

Finally, it must be emphasized that the ankle perforating veins which have been described, particularly the upper and middle on the inside of the leg and the one on the outside, are quite big veins. It is believed that it is by virture of their size and the fact that they lead directly into a high-pressure pump that their incompetence is capable of producing such devastating effects on the subcutaneous tissues in their immediate vicinity (observed and commented upon by Turner Warwick, 1931). It was this reasoning which led the author to try the operative treatment of early ulcers by exploring the region of the ankle perforators and tying the ones which appeared enlarged and incompetent, to be described later in the paper.

THE RESULTS OF VENOGRAPHIC EXAMINATION

A representative cross-section of each of the clinical groups into which we classified the ulcers was examined. The aim of this part of the investigation was (*a*) to determine whether the popliteal and femoral veins were present and patent; (*b*) to determine whether valves were present in them or not; (*c*) to try and demonstrate presence of incompetent perforating veins in the lower leg.

The Technique of Venography.—In order to obtain the information about the patency and configuration of the deep veins, and also to show their valves, a technique of ascending venography using the Valsalva manœuvre was evolved. This is fully described by Gryspeerdt and Cockett (1953).

The technique was as follows: The patient is placed supine with the table tilted 10° downward towards the feet. A vein on the dorsum of the foot is then chosen, preferably not a direct continuation of the saphenous vein, and is exposed under local anæsthesia. A fine polythene catheter, which is connected to a simple positive-pressure drip apparatus, is then inserted into the vein. Once this drip is set going there is no further hurry and one or more injections can be made without disturbing the patient and the positioning can be done at leisure. We found this preferable to direct vein puncture as it was far less disturbing to the patient. One half c.c. of 35 per cent diodone is then injected as a preliminary test dose. After five minutes a light rubber-band tourniquet is placed around the lower third of the leg, leaving at least 6 in. clear above the ankle. Fifty c.c. of 35 per cent diodone are then injected fast, that is in about 15 sec. The exposure of the leg is made just before the final 10 c.c. goes in; the plate under the leg is removed and the lead screen over another plate lying under the thigh is also quickly removed, and exactly 10 sec. later the exposure of the thigh plate is made. Just about 3 sec. before the exposure of the thigh plate the patient performs a forcible Valsalva manœuvre, in which he has previously been drilled. With practice the timing of the various changes of cassettes can be easily achieved. *It is important that at the end of this examination the patient should raise his leg and exercise it vigorously to clear the diodone out of the venous system. If this is not done it tends to remain in the veins for a long time and may cause thrombosis.*

The Question of the Competence of the Valves.—Much confusion has followed the publication of various reports on retrograde or descending venography in which the contrast medium is shown going down as far as the popliteal fossa past apparently normal valves. Such appearances have been reported as showing incompetent valves. Thus Bauer (1948) described retrograde flow by this technique in 30 cases of varicose ulceration and regarded this as evidence of valvular incompetence of the deep veins. Lockhart-Mummery and Hillyer Smitham (1951) show figures of retrograde venograms with 'incompetent' valves. Boyce, Detar, and Vest (1953) also show retrograde venograms using 'Urokon', purporting to show incompetent valves.

In this investigation the presence of a valve in a vein was taken to indicate that that vein was normal and the condition of valves being present but incompetent is not recognized. This is based on a study of 6 young patients with very minor superficial venous incompetence, in whom the performance of a Trendelenburg operation afforded the opportunity to do a descending venogram. Apart from the minor superficial varicose veins the patients had normal legs. Descending venography was performed by passing a small polythene catheter in through the stump of the saphenous vein, so that it was lying in the femoral vein and pointing downwards. The table was then tilted until the patient was nearly upright, the femoral vein compressed above the point of injection and 20 c.c. of 35 per cent diodone were injected. In all cases retrograde flow past the valves, which were always well shown, occurred. In all cases some dye reached the popliteal fossa. *Fig.* 317 shows ascending and retrograde venograms in one of these cases. *Retrograde flow of dye can occur past normal valves and does not constitute grounds for diagnosing valvular incompetence.* This has also been borne out by the appearances during screening. When patients perform a Valsalva manœuvre some considerable retrograde flow occurs before the valves suddenly snap shut. These conclusions are in complete agreement with the work of Dow (1951). These findings would also seem to invalidate the operative test for valvular incompetency described by Bauer (1950).

Thus, in the present series, if one or more valves could be demonstrated in the femoral or popliteal veins they were regarded as normal. The femoral and popliteal veins and deep veins were not regarded as abnormal or recanalized unless no valves at all could be demonstrated in them and their outline and general configuration was irregular. The knowledge of variations of venous anatomy and in the number of normal valves reported in the previous section was of great help in interpreting our venograms.

With these definitions in mind the venographic findings were as follows:—

1. A group of 16 patients with uncomplicated mild superficial varicose veins, with no ulcer or eczema. *Result*: All femoral and popliteal veins found to be normal and valved.

2. A group of 9 patients with superficial incompetent veins of the great saphenous system, and

an ulcer or eczema (clinical group 1). *Result*: All femoral and popliteal veins normal and valved.

3. A group of 4 patients in whom an efficient Trendelenburg operation had failed to control their ulcer. No history of thrombosis. *Result*: All femoral and popliteal veins normal and valved.

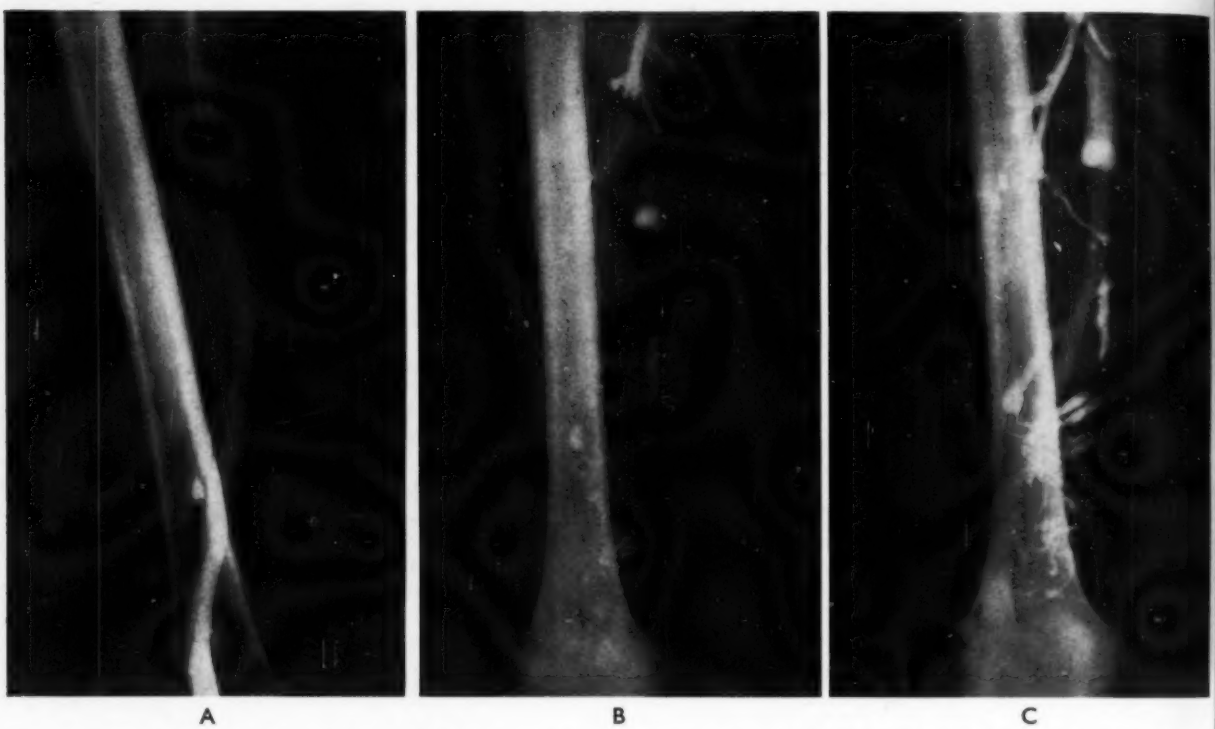
4. A group of 16 patients with ulceration of the lower leg, with no incompetent superficial veins and no history of previous deep thrombosis (clinical group 3). *Result*: Eleven of these patients showed normal femoral and popliteal veins. Five of them showed femoral and popliteal veins which were valveless and irregular and had the appearance of an old recanalized thrombosis.

5. A group of 34 patients who had ulcers or induration of the lower leg, and definite history of white leg or deep femoral thrombosis previously (clinical group 2). *Result*: Thirty-one of these showed patent, irregular, valveless deep channels having the appearance of an old recanalized thrombosis (in 11 of these the deep vein was tied at operation and histological proof of this was obtained). In 3 cases the main deep channels could not be demonstrated. Most of these patients also complained of a good deal of swelling of the leg on standing or walking, and also of pain and aching of the lower leg after standing or walking on it for any length of time, unless it was well supported with an elastic bandage.

Thus from our data two important conclusions were drawn:—

1. That after a deep femoral thrombosis recanalization occurs and is complete in about two years in about 90 per cent of the cases. This is about the time that the major symptoms of œdema, fatigue, aching, and ulceration begin to make their appearance. In a small percentage (probably less than 10 per cent) of cases, recanalization does not occur. (The author has confirmed this at operation on two occasions.)

2. That destruction of valves in the femoral and popliteal veins is *not* a prerequisite for the appearance of ulceration and induration in the lower third of the leg. These veins were normal in over two-thirds of group 3 cases examined and in all group 1 cases.



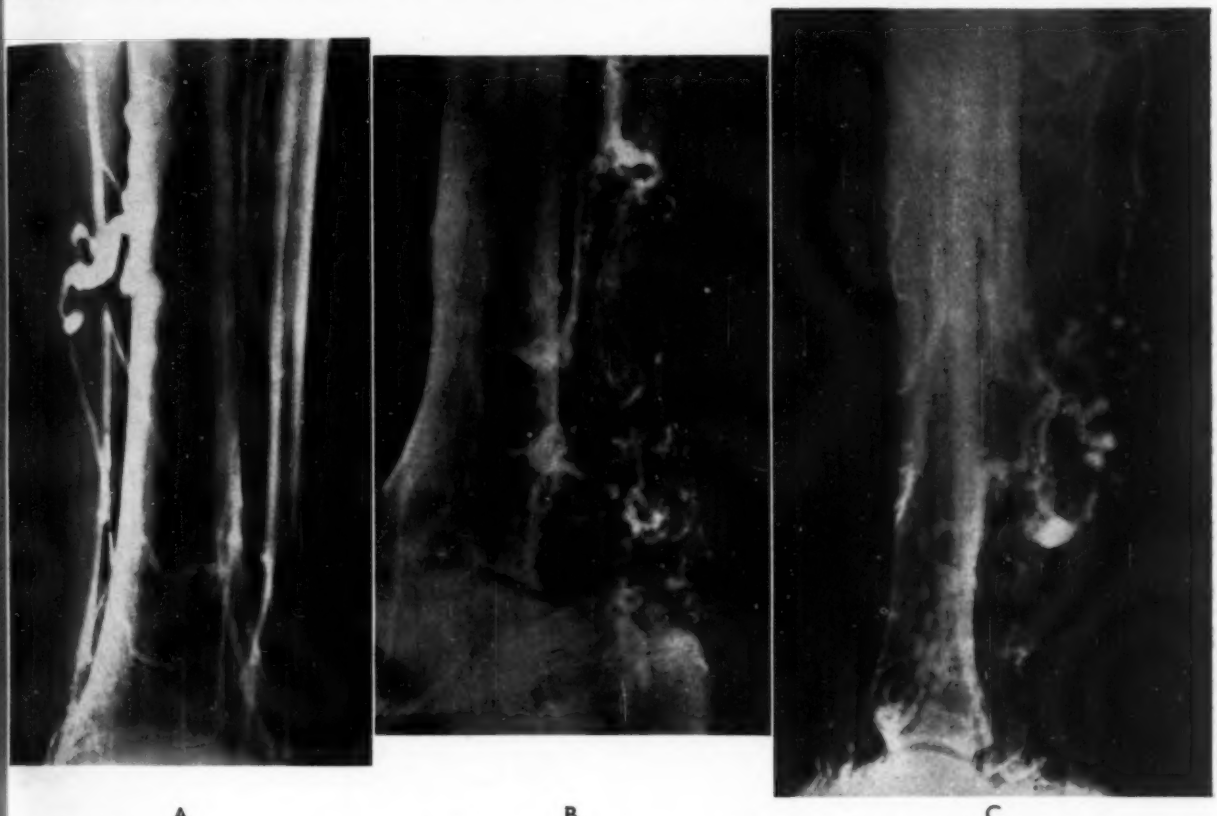
A B C

FIG. 317.—These three venograms are all of the same leg, that of a young man with mild uncomplicated superficial varicose veins.
A, Ascending venogram: Patient flat, no Valsalva. No valves are seen, and there is 'streaming' of the dye in the upper third of the femoral vein.
B, Descending or retrograde venogram. Made by injecting 20 c.c. of 50 per cent diodone into the stump of the great saphenous vein at operation. Patient tilted feet down, and femoral vein occluded above the site of injection.
Note: (1) Valves now shown; (2) Dye can be seen streaming down the vein past the valve cusps, which are not quite shut at the time of making the exposure.
C, Descending or retrograde venogram, made 5 min. after B, but with slower injection and exposure made later.
Note that in both B and C plenty of dye has reached the popliteal fossa, yet these are normal valves in a normal deep vein.

The Demonstration of Incompetent Ankle-perforating Veins by Venography.—The satisfactory demonstration of these veins is unexpectedly difficult. However, the following technique has shown them in a high proportion of cases: With the patient tilted into the standing position, 15 c.c. of 35 per cent diodone is slowly (over 1 minute) instilled into a vein on the dorsum of the foot. Exposures of a plate behind the leg are then made at 15 sec., 30 sec., 45 sec., and 1 min., with a calf contraction between each exposure. *Fig.* 318 shows venograms of incompetent perforating veins made by this technique. It will be appreciated on studying

these venograms that often one of the difficulties here is to sort out and recognize which is the short incompetent perforating vein, as it is often obscured by the mass of dilated veins in the subcutaneous tissues to which it is attached. Sometimes these venograms have been unsatisfactory for this reason.

perforator incompetence and incompetent superficial saphenous system) or becomes long established, it will tend to perpetuate the pathology in the 'gaiter area' even if the original cause of the venous dilatation is cut off (say by ligation of a perforating vein, or ablation of an incompetent saphenous system), for



A B C

FIG. 318.—A, Venogram of the ankle region of a female patient (age 35), who had had a post-partum 'white leg' 2½ years previous to this photograph. She now had an itchy, indurated area over the lower third of her leg which became uncomfortable and 'brawny' when she was on her feet for long. Note the way the subcutaneous tissues are infiltrated with tiny dilated venules, which arise from the incompetent upper internal ankle-perforating vein shown. Note the great saphenous vein passing through the region—obviously normal and undilated. Lastly, note the complete absence of venular dilatation in the subcutaneous tissues just *above* the incompetent perforator (confirmed at operation).

B, Venogram of the ankle region of a female patient (age 45) who had had a post-partum 'white leg' 12 years previously. Again the whole of the subcutaneous tissues of the inner aspect of the ankle are infiltrated with dilated venules, arising from the incompetent perforating vein. In this case, however, the whole area was very indurated and contracted and the site of a large chronic ulcer.

C, Venogram of the ankle region of a female patient (age 50), who had severe varicose veins, with an incompetent great saphenous vein and an area of eczema and ulceration above the internal malleolus. Both the middle and the upper internal ankle-perforating veins (seen in the venogram) were dilated and incompetent at operation, and connected to the mass of dilated veins in the subcutaneous tissues shown in the venogram.

The Venographic Appearances of Ulcers and the Tissues Immediately Beneath Them.—Using the above venographic technique it has also been possible to appreciate the venous pathology immediately under ulcers. Reference to *Fig.* 318 shows the condition usually found. *Fig.* 318 A shows the early pathology of the 'gaiter area' which results in the fibrous plaque and ulcer. The manner in which the whole of the area becomes infiltrated by dilated venules, which arise from the dilated incompetent upper internal ankle-perforating vein is well shown. *Fig.* 318 B shows a later stage of the process in which the sclerosis and ulceration had taken place and been present for some time.

This infiltration of the whole ulcer area by dilated atonic venules forms a sort of 'venous sump' in the ulcer area. If this venous sump consists of large vessels (as it does in many ulcers associated with both these large atonic channels cannot empty efficiently in the erect position and so the venous pressure in the erect position in them will always be of the order of 96 mm. Hg. Thus it is apparent that the only three ways of dealing with this situation are : (*a*) to raise the feet above the heart level—by bed rest ; or (*b*) to apply external pressure directly over it to empty these veins—this is the basis of all ambulatory treatments, where the value of a pressure pad directly over the ulcer is well recognized ; or (*c*) to excise the whole lesion, plus the essential source of venous incompetence whether it be incompetent perforating vein or incompetent saphenous system.

It is apparent from a study of these venograms that in ulcers of long standing the area involved in venous and venular dilatation is widespread, and correspondingly the surgical excision of the area is not likely to be so successful.

THE RESULTS OF VENOUS PRESSURE MEASUREMENTS

The many extensive studies of venous pressures at rest and at exercise in the superficial veins of the foot and leg have produced basic agreement on the following facts :—

1. In normal legs, with the patient erect, the erect venous pressure falls rapidly on exercise to between 0 and 30 mm. Hg, and then rises *slowly* (31 sec. according to Pollack and Wood, 1949) on cessation of exercise to its previous height of 90 mm. Hg.

2. In patients with primary incompetent superficial varicose veins the pressure falls to a value of 45–60 mm. Hg, rising *rapidly* (within 3 sec.) to the initial figure of 90 mm. Hg on cessation of exercise.

3. In post-phlebitic cases there appears to be some variation. Most authors find that there is either no fall—or a slight fall—to a value of 75 or 80 mm. Hg, with an immediate return to the pre-exercise level on cessation of exercise. DeCamp, Ward, and Ochsner (1951) actually recorded a rise in pressure on exercise in 4 cases.

In the deep veins, popliteal and femoral, however, there is no great change of pressure on exercise in any of the three groups. Veal and Hussey (1940) and Sturup and Hojensgard (1950) showed that although there were fluctuations in pressure in these veins during exercise there was no difference in the mean pressure in normal legs or in legs with varicose veins or a history of deep thrombosis, during rest and exercise.

Our investigations on venous pressure were done on 36 cases, comprising a cross-section of the three clinical groups. The method used was that described by Walker and Longland (1950). Our conclusions only are recorded here. These were :—

1. As a diagnostic procedure the measurement of the fall of venous pressure on exercise is not of great assistance. No more help can be got from this examination than can be obtained from simple clinical examination of the leg.

2. The fall of venous pressure recorded on exercise depends on a large number of uncontrollable factors. These are : (*a*) the exact site of the vein chosen (Warren, White, and Belcher, 1949) ; (*b*) the size and pathological state of the actual vein catheterized ; (*c*) the age and general vigour of the patient ; (*d*) the degree to which the calf pump can be exercised, and is exercised ; (*e*) the site and extent of any venous pathology and the time during which it has been present.

In view of the impossibility of adequately controlling all these factors it follows that any detailed deductions as to pathology or results of treatment based on any but the grossest variations of venous pressure over a large series of cases may be misleading.

Thus, in our cases, although there was a general trend for the fall of exercise venous pressure to be least in the post-thrombotic group, a little higher in the varicose ulcer group, and a little higher still in the pure varicose vein group, yet the variation within these groups was so great that the results could not be applied to an individual case.

It is felt that these observations on the extreme variability of the fall of venous pressure on exercise not only in different individuals with the same condition but also in different veins in the same leg, and an appreciation of the numerous factors which may influence the reading, are of importance. There is a tendency to use changes in venous pressure measurements as an indication of the success of some particular operative manœuvre, such as popliteal vein ligation, or as a contra-indication to it. Such evidence must be accepted with some reserve.

THE SURGICAL TREATMENT OF ULCERS

Referring back, it will be seen that on clinical assessment the cases of ulcer considered to be of venous origin fell into three main groups, according to the apparent situation of the venous incompetence :

Group 1 : In which the ulcer was apparently due to incompetent superficial veins of the great or small saphenous system.

Group 2 : In which there was post-thrombotic valve destruction of the whole of the deep venous system following a white leg.

Group 3 : In which no obvious major venous incompetence could be detected in the leg, and in which the ulcer was thought therefore to be due to incompetence of the ankle-perforating veins.

In the section on anatomy, the idea was developed that the final venous pathology which precipitated an ulcer was the localized high venous pressure and consequent dilatation of the venous arches (and small venules arising from them) connected to the three direct internal ankle-perforating veins and the external ankle-perforating vein. It was shown that the necessary increased venous pressure could reach this region by two routes : (1) By incompetence of the ankle-perforating veins ; (2) By incompetence of the great or small saphenous system.

The logical step from these observations was to devise an operation which would do two things : (*a*) Remove the main source of venous incompetence —this involves finding and tying the incompetent perforating vein or veins and/or the incompetent great or small saphenous vein if present ; (*b*) To remove the 'sump' of veins in the subcutaneous tissues of the region—this involves removing the dilated venous arch connecting the ankle-perforating veins and, if necessary, the ulcer *en bloc*.

The decision to try out this new procedure was made for three reasons : (1) It appeared to be the only surgical approach to group 3 cases. (2) The failure of deep vein ligation to control ulceration in many of our group 2 cases. (3) The failure of high saphenous ligation to control the ulceration in many group 1 cases.

Before describing the operative procedure which has been devised the results of two other forms of surgical treatment in our hands must be briefly reported.

Results of Deep Vein Ligation.—Deep vein ligation (either femoral or popliteal) was carried out on 22 cases which were considered to have incompetent, recanalized femoral and popliteal veins following a deep venous thrombosis. Fourteen of these patients have been followed up for from one and a half to two years and so a fair assessment of the effects of this operation on the ulceration could be made. All these cases belong to clinical group 2, and were proved by venography to have valveless patent deep channels. In all but 2, this was proved

correct by the histology of the excised segment of vein.

Our conclusions as to the effects of the operation were as follows :—

1. On ulceration—no effect in 7 out of 10 patients (based on a year to two years follow-up).

2. On swelling—no effect (neither increase nor decrease). (20 cases.)

3. On gravitational pain—marked relief in over half of them. (20 cases.)

We were unable to discern any difference in the effects of popliteal as opposed to femoral vein ligation.

Deep vein ligation alone seemed to have little effect on established ulcers ; all three cases which have remained healed after this procedure were small ones which might well have been healed on support alone. Deep vein ligature combined with a local operation on the ulcer gave much more encouraging results. The effect of the ligature on the calf aching, and general comfort of the limb was striking in over half our cases and has been favourably commented on by all authors on this subject (Bauer, 1950 ; Moore, 1953 ; Walker, 1950). Thus we failed to produce any evidence that deep vein ligation *alone* makes any difference to the course of the lower leg ulceration and induration.

The Results of Sympathectomy.—Sympathectomy, by improving the arterial flow through the skin of the leg, might be expected to improve ulcers of venous origin. Although Walker and Longland (1950) argue against this being the case, Boyd (1952) has reported favourably on this procedure as an ancillary measure in the control of certain venous ulcers. Of course, where ulceration is partly due to arterial ischæmia—as in arteriosclerotic ischæmic legs and severe cases of erythrocyanosis frigida—sympathectomy may help. However, where venous incompetence is the main cause of the ulceration the reported results have not been so good. Linton (1948) says " Lumbar sympathectomy has been used in our clinic in a number of cases, but unless it is combined with some other form of treatment it has not cured the ulceration ".

Our experience has run exactly parallel with this, and is based on the results of treating 16 cases with venous ulcer by sympathectomy (often combined with other measures) over the past three years. A full description of these cases is given elsewhere (Cockett, 1953). Our conclusions on the follow-up of these patients were :—

1. Sympathectomy alone, in general, fails to control ulcers of venous origin.

2. However, in cases in which there is evidence of local arterial ischæmia as well—either arteriosclerosis, erythrocyanosis, or trauma (surgical or otherwise)—it appears that sympathectomy is an effective adjunct to other treatment, such as excision and graft of the ulcer with ligation of perforating veins.

The Surgical Treatment of Ulcers by Ligation of Incompetent Perforating Veins in the Lower Third of the Leg.—The reasons for the reluctance to undertake a direct surgical attack on the ankle-perforating veins have been twofold : (1) A lack of knowledge of the exact situation of the important perforators in the lower leg and the part they play in the genesis of ulceration. (2) A very natural reluctance to operate on an area of the leg which is infected, indurated, œdematous, and which apparently has poor healing powers. Several writers have warned against the dangers of operating in this area, notably Dickson Wright (1953), stressing the fact that the ' surgical ulcer ' is more difficult to cure than the natural one. This is certainly true if the cause underlying it (incompetent perforators) has not been removed.

Before describing the operation adopted, two important points must be emphasized :—

1. *Selection of Patients* : Ulcers are amenable to surgical treatment with a reasonable hope of permanent cure only at a relatively early stage of their natural history. Once the condition has been present for 15 or 20 years and the whole of the lower third of the leg is a mass of indurated fibrous tissue, then ligation of veins is unlikely to affect this established lesion greatly. Attempts at cure by venous ligation at this stage are analogous to closing the stable door after the horse has gone. Such patients are usually in the higher age groups and are more suitable for conservative management along the lines described earlier than for surgical treatment.

Thus it is stressed that the *real place of this operation* is in the relatively early case—*before* the extensive, irreversible changes described have taken place.

2. *Pre-operative Preparation of Patients* : All the patients described here have had a preliminary period of treatment by massage and firm supporting bandages, which has resulted in reduction of the œdema and either complete or partial healing of the ulcer before they come to operation.

Operative Procedure.—Pre-operative skin preparation of the whole leg and foot is carried out with spirit and cetavlon. It is important not to use iodine or flavine on these cases as a certain number react to these agents with an extensive eczema. The patient lies flat on his back on the table with the legs apart and externally rotated. The operator sits at the foot of the table. A slight Trendelenburg tilt to bring the feet *just* above heart level will effectively diminish bleeding. The incision is a straight one which starts nearly half-way up the leg, one fingerbreadth behind the bony margin of the tibia, and is carried straight down to a point 1 in. above and behind the internal malleolus (*Fig.* 319 A). This incision is carried straight down to the deep fascia. If there is an ulcer or healed ulcer or doubtful area of skin in the line of this incision, that area is excised *en route* (*Fig.* 319 B).

Any large veins in the subcutaneous tissues are dissected out and followed up and down ; they lead the operator to one or other of the perforating veins. Usually either the upper or the middle perforator is found to be enlarged. One, or both, are then ligatured at the site of their emergence from the foramina in the deep fascia and the whole plexus of subcutaneous veins is removed. Often a small artery is seen emerging through the same foramen ; this is preserved if possible. Any large veins which go off from the area around towards the back of the ankle to join the small saphenous system or lateral ankle perforator must be carefully followed. These may lead one to a clinically unsuspected incompetent small saphenous vein or incompetent lateral perforating vein. These must then be dealt with through separate incisions.

The whole dissection is carried out *behind* the line of the great saphenous vein itself in this region, which should not necessarily be seen. *All ligaturing is done with fine catgut.* Unabsorbable sutures should never be buried in this region. After hæmostasis has been secured the skin is drawn gently together with fine silkworm gut sutures. All tensions must be avoided.

If an ulcer has been excised during the course of the operation the area is covered with tulle gras. It has been our practice to wait for four to five days for

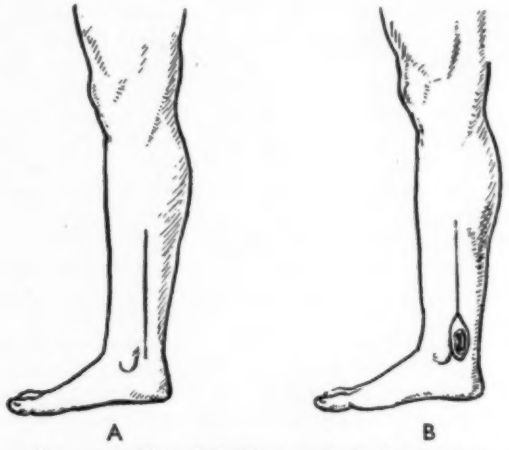


FIG. 319.—Site of incisions used in the operation for exposure of the internal ankle perforators. A, Without ulcer; B, With ulcer or area of 'doubtful' skin.

early granulations to appear on the area before placing a split-skin graft in position at a second operation.

Post-operative Treatment.—

1. A firm elastic webbing bandage is applied from toes to knees, including the ankle, immediately on completion of the operation.

2. It is wise to keep the foot of the bed on blocks for the first 48 hours to lessen the venous congestion of the operative site.

3. Active calf and foot movements are instituted at once.

If there has been merely a straight incision, without ulcer excision, the patient is allowed up on the third or fourth post-operative day with his leg well supported from toes to just below the knee by the elastic webbing bandage. Stitches are removed on the eighth day. The patient may be discharged from the hospital on the fourth or fifth day, but he must be instructed to wear his webbing bandage for three weeks to one month after the operation, until the whole operation area has 'settled down' and feels comfortable.

If an ulcer has been excised and grafting has been done at a second operation the post-operative care is of some importance. The patient should be in bed with feet well raised for about one week after the graft; then he is allowed up for increasing periods with full elastic support (with felt pad over the operation area). We have found it possible to discharge such patients seven to ten days after the grafting on full support, but this must not be relaxed for four to six weeks, when the graft should be well 'bedded in'. After this, some lighter form of support, such as an elastic stocking, is worn for about three months, when the decision as to whether or not to try the leg without any support at all can be made.

Points of Importance in the Operative Technique.—

1. We have considered it preferable not to transgress the deep fascia surrounding the lower third of the soleus. This firm investing layer of deep fascia is an integral part of an efficient calf pump in this region and its destruction may lead to a decrease in efficiency of this calf pump mechanism. This is one respect in which this operation differs from a similar one described by Linton (1953) and practised at the Massachusetts General Hospital, in which a much more extensive *subfascial* dissection of communicating veins is done, followed by removal of a large sheet of this fascia.

2. *A straight* incision, going straight down to the line of emergence of the perforating veins is important. In this way all excessive undercutting of skin is avoided. Undercutting of skin in this region inevitably leads to destruction of more and more of the small perforating arteries and thus increases the possibility of skin necrosis. This point has also been emphasized in the section on anatomy. Linton (1952) also insists on the necessity of using a straight incision in this area.

3. In ligaturing the incompetent perforating veins it is important to ligature them flush up against their emergence from the foramen in the deep fascia, for exactly the same reason that it is important to do it in the Trendelenburg operation. In fact, the operation described here is a Trendelenburg operation, but performed in the lower third of the leg. A large perforating artery is usually seen emerging with the middle perforating vein (*see Fig.* 315), and it is usually possible to leave this intact.

There is one certain way of telling whether a perforating vein is incompetent—by the fact that on cutting across it, or a branch from it, smart back bleeding from the deep veins occurs. If a normal competent perforating vein is cut across no bleeding occurs from the cut end, which goes into the posterior tibial veins as its valve effectively prevents the egress of blood. If a probe is gently pushed into the lumen of the vein and the valve is held aside smart bleeding occurs until the probe is withdrawn. This has been observed at operation three times by us so far. On the other hand an enlarged and incompetent perforating vein bleeds back smartly as soon as it is cut.

Complications.—The most upsetting complication of this operation is necrosis of the skin edges of the incision in the lower leg. Our only case of serious necrosis of the skin was early in the series, when the importance of the pre-operative preparation of the leg and of not undercutting the skin too widely had not been appreciated. This case took four months to heal her necrotic skin incision. After this salutary lesson a good deal more attention was paid to: (1) the choice of case; (2) the pre-operative preparation of the leg; (3) the operative technique; and (4) the meticulous after-care. Since that time there has been no case of serious skin necrosis. Minor skin necrosis confined to a part of the edges of the incision occurs in about one-fifth of the cases; beyond the fact that it delays healing and requires a régime of firm elastic support to the area for a little

longer than normal, it in no way affects the result (these necrotic skin areas should be removed as soon as they form scabs). The incidence of skin necrosis rapidly decreases with the care and experience of the operator. Very few other complications have been observed. There have been a few cases of sepsis (as opposed to skin necrosis), which have responded to drainage and antibiotics. There have been two cases of post-operative calf thrombosis, which settled on a régime of elevation and support, followed by exercise.

No case of pulmonary embolism occurred in this series. We believe that this has been due to the post-operative measures to combat venous stasis in the legs (post-operative elevation and exercises, followed by early ambulations with firm support).

Operative Experience.—The operation described above has been performed on 201 limbs.

The first trials were made on patients of clinical group 3, and in patients who had recurrent ulcers after an efficient Trendelenburg procedure. The results were so encouraging that the operation was extended to all clinical groups.

1. In 135 limbs with early and late indurative lesions and ulcers of the ankle, without incompetent superficial veins of the great saphenous system, incompetent ankle-perforating veins were found, proved incompetent by Turner Warwick's test, and tied in 96. The veins found incompetent in this series were :—

96 *Cases*

Upper internal ankle perforator incompetent only	24
Middle internal ankle perforator incompetent only	55
Both internal ankle perforators incompetent	4
Lower internal ankle perforator incompetent (not explored in every case)	0
Lateral ankle perforator incompetent only	12
Anomalous origin of small saphenous perforating low down in calf	1
	96

Thus the middle internal or the upper internal ankle-perforating vein was the site of venous incompetence underlying the ulcer in the majority of cases. However, in just over 12 per cent of the cases the lateral ankle perforator was found incompetent even when most of the pathology was on the inner side of the leg. By means of the vein passing medially behind the tendo Achillis the effects of incompetence of this lateral perforator may be distributed to the internal surface of the ankle as well as the external surface.

2. In 12 limbs in which an ulcer had recurred or persisted in spite of an efficient Trendelenburg operation, and often multiple ligations of the great saphenous system as well, incompetent perforators were found in every case.

12 *Cases*

Upper internal ankle perforator incompetent only	5
Middle internal ankle perforator incompetent only	4
Both internal ankle perforators incompetent	2
Lateral ankle perforator incompetent only	1
	12

3. Fifty-four cases with obvious incompetence of the great saphenous system and indurative lesions of the lower leg of varying degrees of severity were also operated upon. These cases had a routine Trendelenburg operation, often a stripping of the veins of the great saphenous system, and an exploration of the ankle perforators. The results were :—

54 *Cases*

Cases in which no incompetent perforator in the lower leg could be demonstrated	18
Cases in which either the upper (8 cases) or the middle (28 cases) ankle perforators were found incompetent	36
	54

Thus from these figures it would appear that in approximately 66 per cent of cases with varicose veins and a lesion in the lower leg, an incompetent perforating vein is also present, and is contributory to the lower leg lesion. It was noticeable that those with the most severe lesions always had an incompetent perforating vein as well. This is the reason why so many varicose ulcers recur after an efficient operation on the great saphenous system, because the incompetent perforator near the ulcer is left behind and perpetuates the ulcer as soon as normal activity is resumed.

Follow-up Results.—It is notorious that any operation purporting to ameliorate or cure ulceration of the leg must be judged in the light of a follow-up of three to four years at least. Moreover the result may be influenced by a large number of ancillary factors, such as : (1) The effective elastic support which may be given at the same time ; (2) A period of bed rest (which in itself tends to heal venous ulcers) ; (3) Change of occupation (from a job on the feet to a more sedentary occupation).

In the light of all these known facts, however, this operation has given by far the most promising result yet seen in our clinic. The patient shown in *Fig.* 320 is typical. It is three and a half years since her operation and for the last two years she has been back at full housework, with no supporting bandages of any sort. Most of the patients of clinical groups 1 (so-called varicose ulcers) and 3 (' ankle blow-out syndrome ') have either discarded all support or are occasional wearers of elastic stockings (that is to say they wear elastic stockings at housework or at work, but discard them for outings). However, most of the patients of clinical group 2 (post-thrombotic limbs, in which there has been in addition to incompetent perforators, complete destruction and recanalization of the deep system) have continued to wear heavy elastic stockings. Nevertheless, even in these patients it has been striking how the operation has helped maintenance of sound healing of the ulcer, and has made the leg feel much ' easier '.

There has been no post-operative recurrence of ulceration in this group, where an incompetent ankle-perforating vein has actually been found and tied, during the somewhat limited follow-up period. It is hoped to present a full and detailed follow-up of this group of patients in a further two years' time.

Subfascial Ligation of Perforating Veins.—In those more advanced cases in which the woody induration of the lower third of the leg has effectively obliterated all the subcutaneous tissue planes, a *subfascial* ligation of the ankle-perforating veins is the only possible approach. This is done through an incision parallel to, but about ½ in. posterior to, the one shown in *Fig.* 319. The incision is carried straight down to the muscles, through the deep fascia. The perforating veins are then sought by lifting up

A

C

B

D

FIG. 320.—Mrs. E. H., aged 57. When first seen in 1951 she had had a varicose ulcer for 15 years. A Trendelenburg operation and below-knee excision of varicose veins had been done four years previously, without any effect on the ulcer. In October, 1951, she was re-admitted and two more fairly prominent below-knee veins were dissected out. The ulcer healed in hospital, but one month after discharge it was as big as ever.

A venogram was then done. This showed a normal femoral vein. Under the ulcer area a large vein was seen which appeared to arise from a perforating vein in the lower third of the leg (*see* photograph).

In April, 1952, she was re-admitted and after a lumbar sympathectomy the whole area of the ankle-perforating veins was explored. The incompetent perforator was found and ligatured and the veins under the ulcer and the ulcer itself were removed in one piece. The resulting defect was grafted with a split-skin graft.

A, Pre-operative state. Ulcer had been present for 15 years. B, Venogram of lower leg, showing incompetent perforator and vein leading down to ulcer. C, Three days after operation. D, Shows the leg one year after operation. She is now doing a full day's housework without any supporting bandages at all. The graft has consolidated well and there is no sign of breakdown or recurrence.

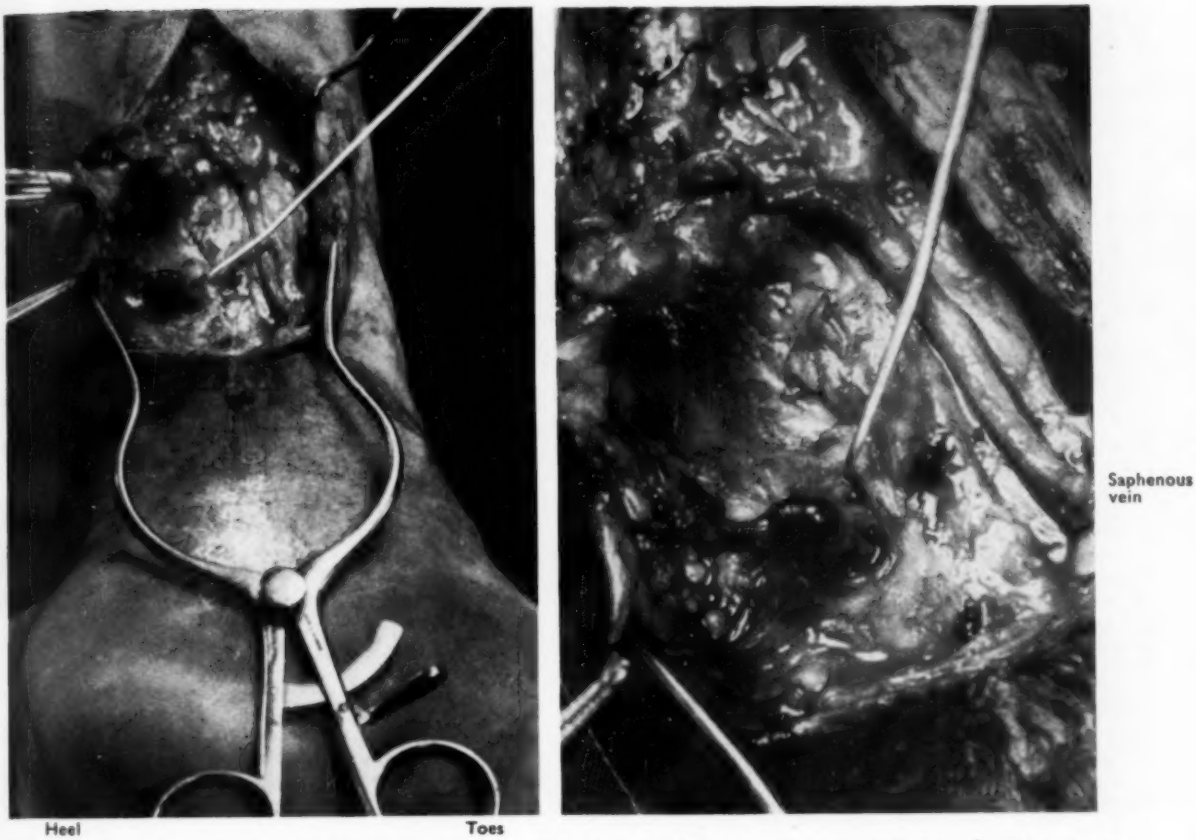


FIG. 321.—Operative photograph of the inner aspect of the ankle region, showing an incompetent middle interna ankle perforator. Note the position of the perforator, well posterior to the saphenous vein. The probe is in the sharp-edged foramen in the deep fascia through which the perforator emerges.

the anterior flap and ligating them as they emerge from the muscles. The results of this type of operation for this particular group (as described by Linton, 1953; Sherman, 1949; and Wright, 1953) will not be discussed here as sufficient follow-up time has not elapsed in our cases, which are inevitably some of the more advanced ones. The early results are promising.

SUMMARY

1. A brief review of the organization of an ulcer clinic is given, and the general routine treatment for ulcers is described.

2. A clinical survey of 234 new cases of ulcer of the leg seen over a period of two years is made. It is shown that of the ulcers of venous origin, 52 per cent only have an incompetent great or small saphenous system, 21 per cent have a definite history of previous femoral thrombosis or 'white leg', and 27 per cent have neither incompetent saphenous system, nor definite history of thrombosis. These three groups of cases are designated groups 1, 2, and 3 respectively.

3. A detailed description of the anatomy of the superficial and deep veins of the leg is given. Particular attention is given to the anatomy of the venous drainage of the soleus muscle, and to the anatomy of the perforating veins in the lower third of the leg. It is shown that in the erect position, the main drainage of the ulcer-bearing area of the leg is by these perforating veins.

4. The results of venographic investigation of 90 selected patients belonging to clinical groups 1, 2, and 3 are given. The aims and technique of venography are discussed. It is shown that a large proportion of limbs with ulceration and induration of the lower leg have normal femoral and popliteal veins with normal valves (including a proportion of the post-phlebitic ulcers without superficial varicose veins). The demonstration of incompetent perforating veins in the lower third of the leg, and of the venous pathology underlying ulcers, by venography is described.

5. The results and conclusions from measurements of resting and ambulatory venous pressures are given.

6. The surgical treatment of ulcers of venous origin is discussed. The results of deep vein ligation, and sympathectomy, in selected cases are given.

The thesis that venous ulcers and induration of the lower leg are usually due to destruction of the valves in the ankle-perforating veins is put forward and supported by clinical, venographic, anatomical, and experimental evidence. Based on this thesis, an operation for the extrafascial ligation of these incompetent perforators and excision of the ulcer (if present) is described. The experience and early results of this operation in 201 limbs are described. In over two-thirds of the cases of so-called varicose ulcer (with grossly incompetent great or small saphenous system) incompetent ankle perforators

are found as well, and if not dealt with are the cause of ulcer recurrence.

7. The incisions in the lower leg heal well without trouble, *provided* that the requisite routine pre-operative and post-operative care is followed.

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GUNSHOT AND SWORD WOUNDS OF THORAX AND ABDOMEN

By E. GRATTAN

FROM THE THORACO-ABDOMINAL SURGICAL UNIT OF THE KING GEORGE VI HOSPITAL, NAIROBI

LITTLE has appeared in the medical press relating to the injuries sustained in the conflict taking place in Kenya; papers have been published relating to the warfare in Korea and Malaya, and it may not be deemed presumptuous to send this account of a series of chest and abdominal casualties which have been met with in the East African campaign.

Between August, 1952, and November, 1953, a considerable number of African* patients with severe gunshot or sword wounds of the chest or abdomen, or of both these compartments of the body, have been seen at the King George VI Hospital, Nairobi. The majority of the patients have been Mau Mau victims; the remainder have been Mau Mau adherents shot by the police while breaking the law; there have also been seen during the period under review many Africans shot by the Mau Mau who have been beyond medical aid and others, men, women, and children, hacked to death or strangled. It is perhaps permissible to speculate as to the mental age of the aggressor, so destructive has he shown himself to be! In all, 46 living casualties have been dealt with by thoracic and abdominal unit; the number does not include patients with minor gunshot wounds, which have been numerous during the same period, or the panga (sword) wounds of the Lari Massacre. Head and neck and spinal gunshot wounds have been dealt with by other departments of this hospital, and a few abdominal gunshot wounds have found their way to other emergency surgeons.

Of the severe cases which constitute this series 10 have died and 36 have lived; most of the patients have been admitted within two or three hours of wounding; happily the last 13 consecutive admissions in this series have all survived.

Table I gives some indication of the type of injury dealt with. Apart from wounds of the lung or small gut which may frequently be the only anatomical region implicated, the majority of wounds were almost invariably complicated by injury elsewhere in the abdomen or chest. There were 5

Table I.—SITES OF INJURY

No. of Cases	Organ Injured	Treatment	Percentage Survival
2	Entry and exit wound(s) of lung(s) with lung bruising	Penicillin 'cover'. Coughing exercises. Oxygen if necessary	100
9	Entry and exit wound(s) of lung(s) with pneumo-hæmothorax and lung bruising	Penicillin 'cover'. Repeated aspiration. Breathing exercises. Coughing exercises. Oxygen	100
7	Entry and exit wound(s) of lung(s) with heavily bruised lungs complicated by abdominal injuries or gross hæmothorax	Thoracotomy for gross bleeding or laparotomy for abdominal injuries; but *see* text for details	28·6
1	Entry and exit wound(s) of lung(s) with tension pneumothorax and mediastinal emphysema	Penicillin 'cover'. Repeated aspiration. Too restless for under water drainage	100
5	Sucking wound(s) of lung(s), usually sword wounds, with or without pneumohæmothorax	Closure under local anæsthesia. Penicillin 'cover'. Repeated aspiration. Breathing exercises	100
8	Perforating wound(s) of stomach alone or with other injuries	Closure of perforations. Penicillin 'cover'	62·5
6	Small-gut perforations alone	Suture of perforations with one layer of interrupted cotton. Penicillin 'cover'	83·4
9	Small-gut perforations with other injuries	Suture, as above. Penicillin 'cover'	66·6
9	Large-gut perforations complicated by other abdominal injuries in 4 cases, and by lung injuries in 2 cases	Suture of perforations, or resection, with two layers of interrupted cotton. No colostomy except in 1 case. Penicillin with streptomycin 'cover'	77·7
2	Rectum, with other abdominal injuries	Suture of perforations, with colostomy in first case only. Penicillin 'cover' with strepto-mycin	100
4	Liver alone or complicated by other injuries, including one case of paraplegia at level of 7th thoracic segment, with bed-sores and tetanus	Suture of perforations or lacerations, with drainage for large lacerations. Penicillin 'cover'	75
2	Pancreas, with other injuries	Suture without drainage. Penicillin 'cover'	50
3	Kidney or renal pedicle, with other injuries	Nephrectomy by medial mobilization of colon. Penicillin 'cover'	66·6
3	Spleen, with other injuries or splenic pedicle with other major injuries	Splenectomy. Penicillin 'cover'	0

* Asian and European cases have been dealt with at other hospitals.

sword wounds, 4 of these being sucking wounds of the chest; 41 were gunshot wounds, usually multiple bullet wounds.

DISCUSSION WITH ILLUSTRATIVE CASES

ABDOMEN

1. Hæmostasis.—One of the main objectives of laparotomy in the case if penetrating wounds of the abdomen is the arrest of hæmorrhage. Failure in this objective seems to be related to the anatomical inaccessibility of damaged viscera, as for example the pancreas, and also to such circumstances as the conduct of an operation where the blood-pressure has been so low that bleeding has actually ceased, but re-commences again after the patient returns to bed.

The usual cause of death in our series of abdominal wounds dealt with surgically has been a further intraperitoneal hæmorrhage occurring within the first 24 hours; the latter is far more lethal than operation shock and if superadded to this has invariably proved fatal, despite replacement of blood by transfusion and other normal resuscitation measures. In certain instances where hæmostasis at the site of injury at the time of the primary operation appears to be quite impracticable, it is suggested that ligature of the main supplying vessels in continuity might be worth employment.

Case No. 4797.—Admitted May 5, 1953, death May 6. Entry wound near anus, exit wound anteriorly in the right iliac fossa, with prolapsed small gut coming through wound: patient severely shocked and almost moribund. Intra-arterial injection of saline and also intravenous saline and blood with immediate laparotomy. Prolapsed gut replaced; perforations in small gut repaired; intraperitoneal bleeding was coming from bullet track on the right wall of pelvis from branches of right internal iliac artery and/or vein, but the tissue destruction was so great that no individual point could be picked up. Owing to the critical state of the patient, the track was packed and the pack led out extraperitoneally. The patient died 12 hours later, and at autopsy bleeding was found to have continued from the bullet track on the lateral wall of pelvis, but the anatomy was too destroyed to indicate precisely the vessels involved. Ureter and bladder seriously bruised. Packing had obviously been insufficient and individual ligature would have been impossible; ligature of the internal iliac artery and vein in conjunction with extraperitoneal packing might have solved the problem of incomplete hæmostasis.

2. Auto-transfusion.—If blood is present in the abdominal cavity it can on occasion be sucked out, passed into citrate bottles, filtered through gauze and re-transfused; we have even used blood which has been grossly contaminated with fæces without ill effect; of course this practice is not recommended if sufficient donor blood is available.

3. Peritoneal Cleaning, Closure of Perforations, and the Time Factor.—It is unnecessary to emphasize the necessity of effective suction of spilled intestinal contents and blood, careful cleaning of the peritoneum by dry sponging, etc. There must be no wastage of time, but the efficiency in obtaining the surgical objectives of the laparotomy should not be sacrificed to speed. None of the cases in this series that ended fatally died, as far as could be judged, from the shock of a prolonged operation: always at autopsy some damage had been overlooked.

Eight cases of large-gut injury, the majority showing multiple lacerations, and 1 case of rectal injury have been treated by wound excision and suture or by resection without a single patient giving evidence clinically or post-mortem of leakage or peritonitis, in spite of the gut having been returned to the abdomen without a colostomy or cæcostomy.

We are aware that the practice of exteriorization of the injured colon which we owe to the wisdom and vision of Sir Heneage Ogilvie remained almost unchallenged throughout the years of the Second World War and that it has been hailed as one of the definite advances in the surgery of war, a technical advance which saved the lives of thousands of wounded men. The history of the abdominal surgery of the 1939–45 conflagration, however, does indicate that there arose doubts and misgivings about exteriorization of wounds of the cæcum and right-sided colon (Gordon-Taylor and others). Our favourable experience of abdominal injuries of the colon in Kenya treated by non-exteriorization methods prompts us to suggest with all diffidence that only where there is doubt about the degree of bruising or viability, and where resection is precluded by the state of the patient, should exteriorization be performed, and that proximal colostomy is required only for extraperitoneal injuries of the rectum which are inaccessible to suture. Careful interrupted suturing of colonic lacerations in two layers is undertaken, and of course in extraperitoneal injuries a drain is left down to the site of laceration; streptomycin has been used recently as post-operative cover. Of the two early cases in which proximal colostomy was performed, one developed a severe general peritonitis.

Case 7490.—A very shocked patient with obvious intraperitoneal hæmorrhage. Admitted July 14, discharged Aug. 17.

Immediate laparotomy showed a large tear of the splenic flexure of the colon, two large holes in the jejunum, a perforation in the mesenetry of the sigmoid colon, and retroperitoneally a lacerated upper pole of the left kidney. The tears in the large and small gut were repaired with interrupted cotton, the sigmoid mesentery closed, the left kidney removed, and the peritoneum cleaned; three pints of fæcal-contaminated intraperitoneal blood were re-transfused to the patient, after filtering through twelve thicknesses of gauze during the operation. No colostomy was performed. Recovery uneventful, except for some mild abdominal distension for the first few days. Culture of the contaminated blood showed coliform and other organisms.

PENETRATING WOUNDS OF THE CHEST

1. Routine for Hæmothorax Treatment.—For the majority of cases of hæmothorax due to through-and-through gunshot wounds, particularly where there is lung bruising, conservative treatment is the appropriate procedure. Experience has taught us that if early routine aspiration yields intrapleural blood amounting to no more than two to three pints, and if subsequently the general condition remains stationary or improves, operative interference is contra-indicated. Where doubt exists a further aspiration is performed one hour after the first, and if a lesser amount of blood is withdrawn than at the first aspiration, this is regarded as added evidence of the success of conservative treatment; all blood aspirated has been re-transfused. Our

experience confirms the well-known view that aspiration does not increase the risk of re-starting hæmorrhage. Only if more than two or three pints of blood are withdrawn initially is thoracotomy considered, and if half an hour later a not diminishing amount is again withdrawn, our practice has been to proceed to immediate thoracotomy. In cases of hæmothorax or pneumohæmothorax treated by conservative methods of aspiration and re-aspiration, further aspiration is performed at the end of 24 or 48 hours and thereafter daily or every other day until the pleural cavity is dry and the lung fully expanded; ideally the latter occurs within ten days of the injury. Streptokinase-streptodornase is injected in the case of clotted hæmothorax immediately this is diagnosed, the injection being repeated if necessary. Systemic penicillin 'cover' has been used during the conservative treatment of all cases of hæmothorax; no empyemata have occurred. Despite the fact that in the majority of instances the bullet track or tracks have passed through the lung substance, there have been no bronchopleural fistulæ; all have obtained full lung expansion. Fortunately no bullets have been retained in the lungs; all the cases have been through-and-through wounds, or the bullet has lodged in the chest wall, where removal is not a necessity.

2. Bruised Lung Syndrome.—We would like to suggest that a name, perhaps that of 'bruised lung syndrome', be given to the extensive bruising which occurs in lung tissue immediately following the passage of a high-velocity missile through or near its substance; this hæmatoma formation was described by Nicholson (1946) and is of course well known, and the lethal character of the lesion is mentioned, but perhaps not sufficiently emphasized.

The clinical signs associated with this 'bruised lung syndrome' are deficiency in air entry, variable medium crepitations and rhonchi, a varying amount of respiratory distress and the presence of blood-stained sputum; post-mortem findings on 5 cases suggest that the area of bruising of the lung is usually of greater extent than the clinical signs appear to indicate. Even when only one bullet has traversed or passed near to one lung only, the whole of that lung and two-thirds of the other lung may be involved. Repeated radiographs have not helped materially in diagnosis, except in two cases which showed increased density of lung shadow, but only a portable apparatus has been available in the majority of instances and the lung detail is often obscured by some degree of pneumohæmothorax.

The third and fourth days constitute the critical period for bruised lung patients, irrespective of whether a hæmothorax is present or not, and if death occurs, it appears to be due to the loss of alveolar air space in the almost solid bruised lung, which post mortem sinks in water and microscopically shows erythrocytes within the alveoli, and to partial blocking of the bronchial tree with blood-stained mucus. It seems highly important to recognize this syndrome so that any general anæsthesia for further surgical procedures contemplated during the first week or two may be avoided. Treatment is directed towards keeping a clear airway, coughing and breathing exercises, bronchoscopic suction or tracheotomy if the condition deteriorates, and full oxygenation.

3. Open Sucking Wounds.—The simplest and quickest form of treatment is closure with a gauze pack, and this suffices as a first-aid measure, but preferably within eight hours of injury the wound should be cleaned and, if necessary, excised under local anæsthesia and closed in layers without tension. The use of local anæsthesia is advisable, because these patients are often severely shocked and in gunshot wound cases there may be an underlying bruised lung; where the lung is extensively lacerated (i.e., to a depth of more than 1½ in.), the laceration should be closed lightly, and in such a case the risk of general anæsthesia and formal thoracotomy to obtain good access may have to be taken, and any fragment or foreign body in lung or pleural cavity should be removed.

Case No. 16399.—Admitted Dec. 31, 1952, discharged April 15, 1953.

Brought from Thika (24 miles from Nairobi) in an almost pulseless condition but conscious, suffering from multiple panga wounds inflicted twenty-four hours previously: there were two of the chest, one of the scalp, and another almost completely severing the left arm at elbow. The chest wounds were as follows: right upper chest posteriorly 8 in. long dividing all muscles down to ribs; the second, third, fourth, and fifth ribs were sectioned along with intercostal vessels. Pleura was open and lung protruding through wound, caught between divided rib ends. Other chest wounds 4 in. long through all muscles of left chest posteriorly, but not involving ribs or pleura. Intravenous fluids administered, but no blood was available; wound cleaned and grass and debris removed; closure with replacement of right lung into pleural cavity under local anæsthetic; uneventful recovery with penicillin and sulphathiazole 'cover'. Full lung expansion; no pleural fluid; slight superficial wound infection only.

COMBINED THORACO-ABDOMINAL INJURIES

It is well known that the mortality figures for combined injuries are higher than for each compartment separately; this has also been borne out in our experience in Kenya. In such cases we have regarded the abdominal injury as having the higher priority for surgical intervention. Inasmuch as the great majority of cases coming to operation were bullet wounds, the chest condition, hæmothorax, and/or bruised lung could often be safely dealt with conservatively.

Case No. 9011.—Admitted restless, but not heavily shocked, Aug. 22, 1953, discharged Sept. 19.

Bullet wounds of left chest, of upper left abdomen and left arm and forearm. Resuscitation, oxygen, intravenous saline and blood, followed by immediate laparotomy which showed two wounds in the left diaphragm, a small laceration of liver, two wounds of transverse colon; all perforations sewn up with interrupted cotton; small sucking wound of left chest explored and closed; hæmothorax aspirated, less than one pint withdrawn; arm wounds excised where necessary. Twenty-four hours later left hæmothorax re-aspirated, one pint withdrawn; abdomen soft; some respiratory distress continued till the fourth day.

This was an example of a thoraco-abdominal injury with the bruised lung syndrome, tending towards revovery on the critical fourth day.

Table II gives the mortality figures which emerge from this study. We have had the advantage over the surgeons of the Second World War in that the

majority of casualties were admitted within two to three hours of wounding; on the other hand, we were dealing with Africans, who seem in general to withstand major operations less well than Europeans, and no case admitted alive has been refused operation; the type of laceration to gut does not appear to have been less in severity than that caused by bomb fragments, many of the cases having been shot at close range; fæcal contamination of the peritoneum has been usual, and even an occasional round worm or tapeworm has found its way out of the perforated gut.

Table II.—MORTALITY PERCENTAGES

Compartment of Body	*No. of Cases*	*Percentage Mortality*
Chest alone	17	12
Abdomen alone	22	18
Small intestine alone	6	16·6
Colon alone or with other abdominal injuries	7	14·3
Chest and abdomen	7	57·2

The mortality figures for this series are comparable with those quoted for the last world war (Ogilvie, 1945, chest 13 per cent, abdomen 30 per cent, chest and abdomen 50 per cent) with the exception that the small number of thoraco-abdominal injuries show a higher mortality figure, which may be attributable to the very extensive lung bruising that we have observed. On the other hand, our abdominal mortality figures, especially those associated with large-gut injuries alone or with other abdominal injuries, are lower, 14·3 per cent instead of the 39–60 per cent quoted by the *British Journal of Surgery* War Supplement No. 3; the method of dealing with large bowel without exteriorization may be worthy of some consideration in certain cases, particularly in an era of increasing potency of antibiotics.

SUMMARY

1. In the case of intra- or extraperitoneal wounds of the large bowel we have not employed exteriorization or proximal colostomy, but have made use of careful suture of perforations or performed resection and anastomosis with interrupted non-absorbable stitches; extraperitoneal injuries must of course have a drain left down to the site of repairs; streptomycin and penicillin 'cover' is advised.

2. A generous laparotomy incision has always been used, usually a paremedian incision extending from the symphysis pubis to xiphisternum; no complications related to the size of the incision have been met with.

3. It is hardly necessary to emphasize the importance of good lighting and the provision of suction apparatus. A first-class anæsthetist is the surgeon's greatest ally.

4. In this small series peritonitis has not been a frequent complication after laparotomy for gunshot wounds of the abdomen, with penicillin and latterly with streptomycin 'cover'.

5. In the abdomen time-consuming operations, even in the most desperate cases, do not appear to have aggravated the condition of shock provided satisfactory hæmostasis has been attained: any further post-operative intraperitoneal bleeding is invariably fatal, and a secondary laparotomy for control of further hæmorrhage is a lethal substitute for a 'rushed' first exploration.

6. Injuries of the kidneys in patients seen early may not necessarily show blood in the urine.

7. Our experience confirms the well-known view that for most abdominal operations the earlier the operation is performed the better the prognosis; in extreme cases of shock, when it is thought that active bleeding is proceeding, resuscitation should not be allowed to delay laparotomy, which should be performed at the same time, blood, if necessary, being given under pressure by an intra-arterial route; both peritoneal contamination and bleeding usually increase with waiting.

8. Many chest injuries do well with conservative treatment; hæmorrhage usually ceases spontaneously, collection and re-transfusion of the intrapleural blood by aspiration has proved easy and effective, and thoracotomy has often not been necessary. Lung healing and re-expansion have not been a problem.

9. Bruising of the lung is a serious complication of gunshot wounds of the chest, tending to be at its worst or fatal on the third or fourth day after wounding. Oxygen and encouragement in coughing and breathing are required for several days in all cases.

10. If severe deterioration in respiratory function occurs in cases of bruised lung, frequent bronchoscopic suction or tracheotomy may be helpful; general anæsthesia for the surgical treatment of other complications must, if at all possible, be avoided at this critical stage and is inadvisable at any stage except for the first laparotomy or for thoracotomy for excessive intrapleural bleeding.

11. Post-operative teamwork is as important as the more commonly stressed post-operative resuscitation; it cannot be emphasized too often that post-operative complications may arise in these very ill patients and that informed and alert nursing teamwork is essential if such complications are to be noticed early and dealt with effectively. In our experience the complications which are apt not to be recognized sufficiently early are those which require the most urgent treatment; for example, the onset of tension pneumothorax, of atelectasis, of the transition from bowel obstruction to strangulation, of malaria, and pulmonary œdema.

12. Re-transfusion of filtered fæcal-contaminated blood in early operations for abdominal injury has been undertaken when no other blood source has been available.

Addendum.—Seven additional cases of gunshot wounds have been dealt with since the completion of this manuscript of which only 1 has died, this patient having sustained a close-range shotgun wound of the liver which had a hole in it the size of a woman's fist, along with right lung bruising and perforations of gut. Included in this number are 2 further extensive lacerations of the large gut which were treated without colostomy.

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helpfulness; to the Senior Medical Officer, Dr. Harris, for his active support, and to the Director of Medical Services, Kenya, Dr. Farnworth Anderson, for his permission to publish these notes on wounds of the abdomen and chest sustained in the fighting in this region of Africa.

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RUPTURED SPLEEN

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IN the course of a survey of the cases of traumatic rupture of the spleen treated in Addenbrooke's Hospital during the past ten years, some facts came to light which, in view of the comparative rarity of the condition, it was thought worth putting on record.

The series consists of 16 cases from Addenbrooke's Hospital; 1 further case, treated in Huntingdon Hospital, has been added since it presented features of some interest. All were closed injuries with no external wound and all were treated by splenectomy. There was 1 death.

It is possible that the condition is commoner than in the past, 14 of the 17 cases in this series having been treated in the last five years of the decade. On the other hand this may well be connected with the fact that there was a greater volume of civilian motor traffic on the roads in the years 1948–52 as compared with the previous five years, for, in 7 of the 14 cases in which the necessary information is available, the injury causing splenic rupture was sustained in a motor-car or motor-cycle accident.

THE NATURE OF THE INJURY

Of the 14 cases in which details of the injury are available, 7 were classified as severe and 6 of these were due to motor-car or motor-cycle accidents. Seven were mild or moderate injuries, the accidents ranging from a fall off a miniature motor-cycle to a blow in the left loin from the fist of a husband during a domestic disagreement.

Three in the series were less than 15 years old and the injuries of 2 of these were of a very mild nature. Other writers (Waldman, 1947; Pender, 1953) have drawn attention to the fact that, in children, relatively slight injuries may cause unexpectedly severe damage to the spleen.

No less surprising than the mildness of the injury in some cases is the fact that, in more severe injuries, the spleen and no other intraperitoneal viscus is singled out for damage. In 5 out of 17 cases there was evidence of damage to a kidney, but no other intra-abdominal organ suffered. In a series of comparable size Ybarz and Giuria (1951) also found that the left kidney was the only other abdominal viscus ever to be implicated with the spleen. Wilson (1945) found that in a series of 63 non-penetrating abdominal injuries damage to the spleen was almost as common as damage to all other organs added together. His figures were:—

Table I.—DISTRIBUTION OF VISCERAL INJURIES IN 63 CASES OF NON-PENETRATING ABDOMINAL TRAUMA (Wilson, 1945)

	Per cent
Spleen	47·6
Liver	28·6
Intestines	17·5
Mesentery	4·7
Pancreas	1·6

The special susceptibility to injury of the spleen as compared with, say, the liver is of interest. It is difficult to explain the immunity of the latter organ, which presents a larger surface, is more friable, and has less adequate bony and muscular protection than the spleen. It is possible that some other factor as well as direct external violence is involved—perhaps a sudden contraction of the splenic capsular and trabecular muscle in response to fear or anger.

ASSOCIATION WITH OTHER INJURIES

There was no case in this series of injury to any intraperitoneal organ other than the spleen. However, the left kidney was severely injured in 1 case, while in 4 others there was presumptive evidence of renal damage in the form of hæmaturia. The left ribs were fractured in 2 cases; in 1 of these the left lung was also damaged, a pneumohæmothorax being the result, which was successfully treated by repeated pleural aspiration. Rib fractures were given no special treatment.

Using the data from the present series, and those of Roettig, Nusbaum, and Curtis (1943), Wright and Prigot (1939), and Ybarz and Giuria (1951), the incidence of associated injuries to other viscera is found to be as in *Table II*.

The management of concomitant injury to the spleen and left kidney raises some important problems.

No case diagnosed as a ruptured spleen should be operated on without the urine first having been examined for the presence of blood.

Hæmaturia by itself does not, of course, demand anything but an attitude of watchfulness. A ruptured spleen having been discovered and removed at laparotomy, there is very little likelihood, as

Table II shows, that any other intraperitoneal organ has been damaged. However, the possibility of left renal damage is present and a left perirenal hæmatoma should be looked or felt for. If one is present the right course in most cases will be to expose and possibly remove the left kidney. The only death in this series was in a case of a patient who had had a very large hæmorrhage not only from the spleen but also from the left kidney. When the spleen was removed, a left perirenal hæmatoma was noted, but the patient's condition demanded that the operation be terminated with all possible speed. At autopsy the left kidney was found to be torn in half. It is doubtful whether anything could have saved this patient, whose state was desperate from the start. A possible hope would have been to restore his condition at operation by a massive arterial transfusion in order to make left nephrectomy feasible.

Table II.—Association of Other Injuries with Rupture of the Spleen

Total number of cases with ruptured spleen	87
Associated damage to left kidney	18
,, ruptured liver	5
,, pancreatic contusion	1
,, ruptured urinary bladder	1
,, ruptured diaphragm	1
,, retroperitoneal hæmatoma	2
,, fractured ribs with or without lung damage	27
,, brain concussion with or without skull fracture	10
,, broken bones	12
,, perineal tear	1

DIAGNOSIS

So far as can be ascertained from a study of the autopsy records at Addenbrooke's Hospital, no case has died undiagnosed in the period under review, but it is difficult to be quite certain on this point; nor, if there were any who died undiagnosed, were their bodies all necessarily subjected to post-mortem examination. Again, the number of cases submitted to unnecessary laparotomy on the basis of an incorrect diagnosis of ruptured spleen is not known. The writer made this mistake once in the period under review. A correct pre-operative diagnosis was made in 13 out of the 15 cases where this was recorded.

The clinical picture is variable. At one end of the scale is the patient who walks into hospital complaining only of mild abdominal pain. At the other extreme are cases brought in unconscious and almost pulseless from hæmorrhage. The majority lie somewhere between these extremes. They are not desperately ill, but prompt accurate diagnosis and urgent treatment are essential.

In an attempt to assess the diagnostic value of various clinical features, these have been summarized and set out in *Table III*. Only definite positive or negative information has been included. If there was no specific information on a point in the notes, the corresponding space in the table has been left blank.

Slow or Delayed Hæmorrhage from the Torn Spleen.—In most cases there was no difficulty in diagnosis and the patient was operated on within a few hours of injury. Cases where hæmorrhage from the spleen was slow or the rupture of the 'delayed' type are the chief problem. Two in this series were of this nature, the intervals between injury and the first examination being seven days and thirty hours.

The thirty-hour case (*Case* 3), a girl of 10 years, who had fallen off her pedal-cycle, was correctly diagnosed pre-operatively chiefly on account of her complaint of persistent left shoulder pain. The abdominal signs were limited to slight generalized guarding more marked on the right than the left. Her pulse-rate was 115, but otherwise she showed no signs of severe illness and walked into the surgical out-patient department.

The seven-day case (*Case* 11), a man 35 years old, was seen by his general practitioner shortly after his injury. He had cerebral concussion. The spleen was noted to be palpable at the time but was not tender. The patient remained at home but was referred to hospital seven days later. The pre-operative diagnosis was intestinal obstruction, the abdomen being soft and markedly distended, while there was audible peristalsis. The true diagnosis was only revealed at laparotomy.

The History.—It was found in the present series that in most cases a detailed account of the injury was not obtained, the patients remembering only that they had received a blow in the abdomen or flank or had fallen heavily. In 7 out of 15 cases there was a history of temporary loss of consciousness due to a head injury. A clear account of the accident is not to be expected from patients presenting this feature.

Vomiting occurred in 7 out of 12 cases. Its absence from the history by no means reduces the possibility of intra-abdominal hæmorrhage.

Pain is usually felt over the spleen, but this allows considerable variation in its location. It may be in the left lower chest, the left hypochondrium, or the epigastrium. In 1 case it was on the right side, while in 2 others (a slow hæmorrhage and a delayed hæmorrhage) there was no complaint of any abdominal pain. *Case* 12 exemplified a real problem, that of the patient unconscious from a head injury who inevitably has no symptoms.

A complaint of pain over the spleen can be expected in the acute type of case but cannot be relied upon in delayed cases.

Kehr's Sign (pain referred to the region of the left shoulder) is by far the most reliable single sign of ruptured spleen and its absence should cast very serious doubt on the diagnosis. It was absent in only 2 out of the 12 cases in this series where positive information is available on the point. One of these was the case of a man so desperately ill that he was unconscious for most of the six hours during which he was under observation. In another case the shoulder pain was on the right, not the left side, leading to a mistaken diagnosis of ruptured liver. In 5 out of 10 cases it was noted that the shoulder pain was made worse by deep inspiration, coughing, or pressure on the upper abdomen. An obvious, but nevertheless very useful, way of distinguishing referred shoulder pain from pain due to a shoulder injury is that, in the former type, the pain is made no worse by movement of the joint or pressure over the site.

Clinical Signs of Hæmorrhage.—Pallor was a consistent feature in the cases of acute hæmorrhage, but was absent in those patients with slow or

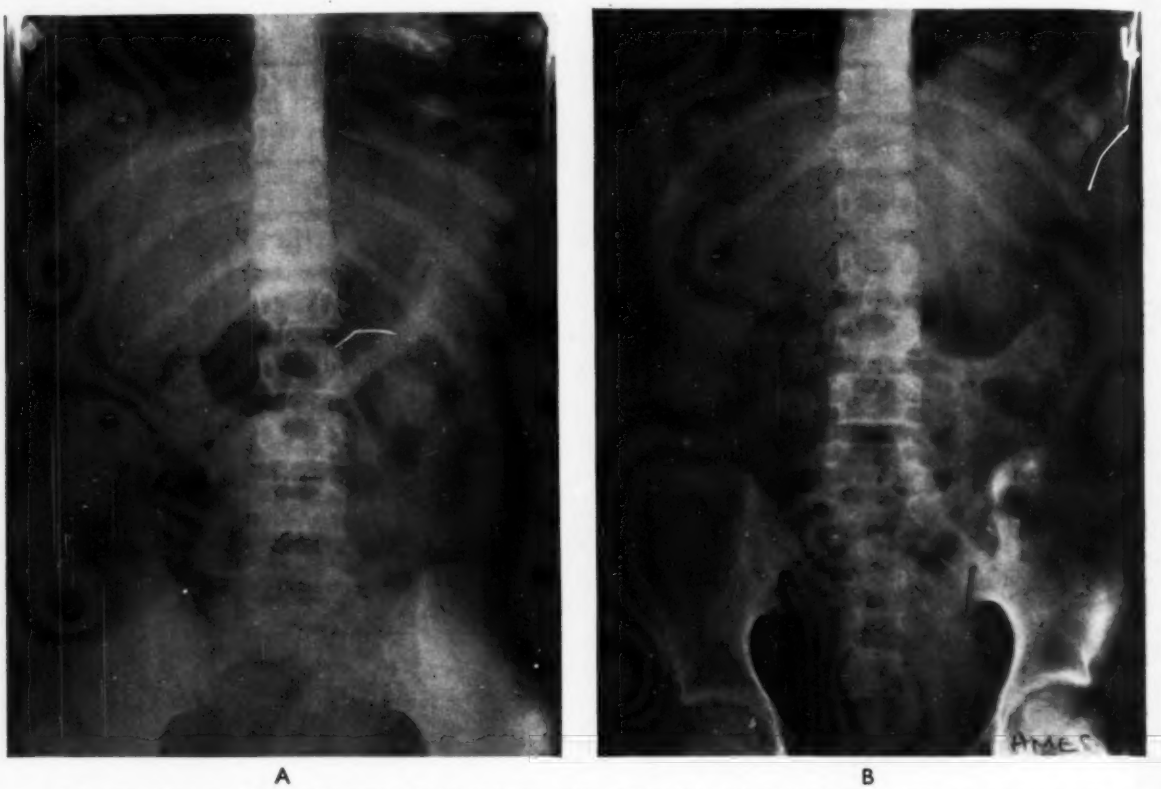
Table III.—Summary of Clinical Features in 17 Cases of Ruptured Spleen

Table III.—Summary of Clinical Features in 17 Cases of Ruptured Spleen

Case No.	Age	Injury—Mild Moderate Severe	Nature of Accident	Time in Hours between Injury and when Seen	History of Vomiting	History of Cerebral Concussion	Site of pain	Site of Abdominal Tenderness and Rigidity	Clinical Signs of Hæmorrhage	Pulse rate/min.	Blood-pressure	Shoulder Pain and Side	Presence of Bowel Sounds	Shifting Dullness	Ballance's Sign	Other Injuries	Pre-operative Diagnosis
1	44	Severe	Motor car	Short	Yes	No	Left hypochondrium	L. hypochondrium and L. side of abdomen	Yes	140	70/?	No	No	—	—	Rupture of left kidney	Ruptured spleen
2	13	Mild	Pedal cycle	4	No	No	Upper abdomen L. chest	L. hypochondrium	Yes	100	116/80	L.	Yes	No	Yes	None	Ruptured spleen
3	10	Mild	Pedal cycle	30	Yes	Yes	None	R. abdomen	No	115	—	L.	Yes	?	No	Lacerations of forehead and lip	Ruptured spleen
4	17	Severe	Motor-cycle	3	No	Yes	—	Upper abdomen and later R.I.F.	Yes	92	105/65	R.	No	No	No	None	Ruptured spleen
5	19	Severe	Motor-cycle	4	No	Yes	L. chest	L. abdomen	Yes	84	95/55	L.	—	No	No	None	Ruptured spleen
6	48	Moderate	Auto-cycle	2½	No	No	Abdomen	L. upper quadrant	Yes	80	115/80	L.	—	?	?	Fractures L. lower ribs. R.B.C. in urine	Ruptured spleen
7	62	Moderate	Fall off straw stack	5	Yes	No	Upper abdomen	Under both costal margins	Yes	68	90/60	L.	No	No	No	None	Ruptured spleen
8	36	Mild	Blow in L. loin from fist	2	No	No	Abdomen	L. hypochondrium	Yes	—	120/80	L.	No	—	—	None	Ruptured spleen
9	21	Moderate	Football accident	4	Yes	No	L. side and abdomen	L. epigastrium	Yes	80	110/80	L.	No	Yes	No	None. Albuminuria for five days following accident	Ruptured spleen ? Ruptured stomach
10	31	—	Fall on back out of tree	9	Yes	No	R. side	R. iliac fossa	No	90	—	—	—	—	—	Definite acute appendicitis	Acute appendicitis*
11	35	—	—	7 days	Yes	Yes	None	None	No	108	128/86	—	Yes ++	—	—	None	Intestinal obstruction
12	18	Severe	Motor-car	—	—	Yes	Unconscious	Unconscious	Yes	140+	—	Uncon.	—	—	—	Blood in urine. L. pneumohæmothorax. Broken 4–11 ribs	Ruptured spleen
13	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	15	—	Kick from a horse	—	—	—	—	—	—	—	—	—	—	—	—	Hæmaturia	—
15	22	Severe	Motor-cycle	<8	Yes	Yes	L. chest and shoulder	L. upper quadrant	Yes	90	110/80	L.	Yes	Yes	Yes	None	Ruptured spleen
16	10	Severe	Motor-car	Short	—	No	L. upper abdomen	L. upper quadrant	Yes	116	90/60	No	Yes	No	No	Laceration of scalp and lower lip	Ruptured spleen
17	16	Severe	Fell 20 ft. on to abdomen	1	No	Yes	L. shoulder and L. upper abdomen	L. upper quadrant	Yes	80	110/75	L.	Yes	—	—	R.B.C. in urine	Ruptured spleen

* This patient developed abdominal pain 24 hours before admission to hospital. Nine hours before admission the pain became suddenly worse causing him to fall out of a tree from which he was picking apples. At operation he was found to have undoubted acute appendicitis and a ruptured spleen. The appendix and spleen were both removed.

delayed bleeding. On the other hand, the pulse-rate, while it was deceptively slow in 5 out of 12 acute cases, was consistently raised above 90 per minute in those with delayed bleeding. In patients such as these, with little else to show, a raised resting pulse-rate may be one of the very few clues to the seriousness of the intra-abdominal condition.



A B

FIG. 322.—*Case* 3. Plain radiographs of the abdomen taken before (A), and after (B) splenectomy for ruptured spleen. In (A) the shadow of the splenic flexure of the colon is shown at the same level as that of the hepatic flexure, whereas in (B) it has returned to its normal, higher position.

The blood-pressure was, generally, not markedly lowered, with the exception of the 1 case with combined severe hæmorrhage from the spleen and left kidney. It was a misleading sign in 1 case and led to an unnecessary laparotomy. The patient, a man of 44, was injured in a car accident and presented with severe pain and tenderness in the left lower chest and upper abdomen. In the course of ten hours his blood-pressure fell from 180/140 to 90/70. Because of this and the persistence of his abdominal signs, a diagnosis of hæmorrhage from a ruptured spleen was made. Laparotomy revealed a normal peritoneal cavity. The patient made an uninterrupted recovery and the cause of his fall in blood-pressure was never elucidated. The significance of the absence of shoulder pain was not appreciated in this case. It is in the highest degree unlikely that a hæmorrhage from a ruptured spleen large enough to reduce the patient's systolic blood-pressure by half would have failed to give rise to referred left shoulder pain.

Abdominal Examination in acute cases reveals, as one would expect, signs of peritoneal irritation in the left upper quadrant. In the 2 late cases the signs were on the right side in 1 case, while in the other there was neither rigidity nor guarding.

Shifting flank dullness on percussion was detected for certain in only 1 case. It was possibly present in 2 others. The sign is of very little value in diagnosis.

Ballance's sign (fixed dullness in the left flank, shifting dullness on the right): The first written reference to this sign appears in a report of a meeting of the Clinical Society of London published in *The Lancet* in February, 1896. Mr. Pitts and Mr. Ballance showed three patients whose ruptured spleens had been successfully removed. They claimed that there was only one other similar case on record, that of Reigner.

One case, a woman of 45 who had been run over by a hansom cab, was observed in hospital for twenty-four hours during which time " an increasing quantity of fluid was collecting in the abdomen ". Eventually " there was dullness on both flanks and ... the dullness of the right flank could be made to disappear by change of position, while the dullness of the left flank remained constant ".

In the other 2 cases the fixed dullness in the left flank was described in rather more hesitant terms: " The dullness could be made to disappear entirely from the right but not entirely from the left "; and " Both flanks were dull but the dullness on the left side could not be wholly got rid of by change of position."

In the present series Ballance's sign was detected in only 2 cases. It appears that, under modern

conditions, the sign is of small value in diagnosis, and it should perhaps be relegated to a less prominent position than that which it now holds in the pages of text-books and the utterances of teachers.

Bowel Sounds.—In acute cases these may or may not be absent. They were present in 4 out of 9 cases in this series. In late cases their presence is to be expected. They were, in fact, so much increased in 1 case that a pre-operative diagnosis of intestinal obstruction was made.

Plain X-ray Examination of the Abdomen.—Levine, Solis-Cohen, and Goldsmith (1946) report that they have observed on plain abdominal radiographs in cases of ruptured spleen :—

1. " Obliteration of the splenic shadow."
2. A jagged, serrated appearance on the greater curvature of the stomach caused by the infiltration of blood into the gastro-splenic ligament.
3. Dilatation of the stomach.
4. Increase in the space between stomach fundus and the concavity of the left diaphragm.

None of these features was observed in the plain films which were taken of cases in this series, probably because they were not specifically sought. However, in 3 cases it was noted that the splenic flexure of the colon was at a lower level than the hepatic flexure. In one of these cases (*Case* 3), a slow hæmorrhage where the diagnosis was not absolutely certain, this reversal of the normal relationship between the two flexures was of definite diagnostic value (*Fig.* 322). How consistent this sign is is not known, but it is recorded here in the belief that it may be of value in the diagnosis of cases where the clinical picture is not otherwise clear.

PATHOLOGY

All the spleens removed were normal, apart from the rupture, with one exception (*Case* 9). In this case the rupture involved a splenic cyst of unknown origin.

TREATMENT

This should always be by splenectomy. It is simple, quick, and safe. Follow-up studies of the patients in this series and by numerous other workers have revealed no serious hæmatological or immunological abnormalities.

Pre-operative Measures.—It is not necessary to enlarge here upon the necessity and indications for blood transfusion. It was used in 9 out of 16 cases in this series.

The stomach is often distended in these cases and the passage of a large-bore stomach-tube just before the induction of anæsthesia adds to the safety of the latter procedure and, by allowing the escape of gastric contents, makes for easier access to the spleen.

The urine should be examined for red blood-cells before operation.

The Operation.—An upper midline incision is the most satisfactory. It gives adequate access to the spleen in most cases, but if necessary can easily be extended by a transverse cut across the left rectus muscle. It is preferred to a left paramedian or left subcostal incision because it is the quickest route into the peritoneal cavity. The reason for the operation is the control of hæmorrhage and, while a hurried scramble is obviously to be deprecated, there is, nevertheless, every reason to adopt a technique which enables one to stop the bleeding in the shortest possible time.

Liquid or clotted blood is usually found lying free in the peritoneal cavity. In some cases, however, the blood stays confined in the left subphrenic space and is only released when a hand is inserted under the left rib margin.

The neatest and most elegant way to remove the spleen is by the classical method of drawing the organ forwards and medially, dividing the lateral leaf of lienorenal ligament under vision and, lastly, securing the splenic and short gastric blood-vessels. However, in cases of rupture it is sometimes advisable to use a different method, for the anatomy of the lienorenal ligament may be completely obscured by the effusion of blood between its layers while it may be impossible to obtain a view of this structure at all owing to the continuous flow of blood from the torn spleen.

In these cases it is best to pull the stomach firmly downwards in the wound and proceed straight away with the division of the gastrosplenic omentum between artery forceps. This peritoneal fold becomes progressively narrower towards its upper end and care should be taken not to injure the greater curvature of the stomach.

As the division proceeds the lateral group of artery forceps, attached to the splenic side of the divided gastrosplenic ligament, are pulled gently downwards and forwards to draw the spleen out of the wound. The main splenic vessels then come into view and are secured. Taking care to identify and avoid the tail of the pancreas and the splenic flexure of the colon, the remaining peritoneal folds attached to the spleen are divided and the organ removed. The left subphrenic space is then cleared completely of blood by the use of the sucker and swabs, the left kidney palpated to make sure that it is not injured and a search made for any other intra-abdominal injury. The abdomen is closed without drainage.

Post-operative Course.—A rather prolonged low fever of up to 100° F. and lasting up to two weeks has been noticed following operation in nearly all these cases. It may be due merely to absorption of blood breakdown products by the peritoneum. On the other hand it may be due in part to collapse and infection of the left lung base. Special attention should be given in the immediate post-operative period to ensuring adequate aeration and drainage of secretions from this part of the bronchial tree.

Pleural effusion should be watched for and treated by repeated aspiration.

There was only one major post-operative complication in this series. *Case* 8, a woman of 36, developed a left anterior subphrenic abscess during convalescence. This was drained through a left subcostal incision, after which recovery was uneventful. In the view of the surgeon who did the operation this abscess was the result of damage to the greater curvature of the stomach inflicted during the ligation of the highest of the short gastric vessels. The gastrosplenic ligament was very short and, in addition, the anatomy of the part was obscured by

an effusion of blood between the peritoneal layers. It is easy, under these conditions, to include the stomach wall in the grasp of the hæmostat applied to the gastrosplenic ligament. A small, temporary gastroperitoneal fistula follows and results in a subphrenic abscess.

Late Follow-up.—Twelve cases have been personally interviewed and examined, the interval between operation and follow-up varying from two months to four years.

Four thought that they tired more easily than before the operation, or were less energetic. One, a girl of 10 years, said that she experienced occasional pain in the left shoulder. She, curiously enough, was one of the only two patients in the series who had not had referred shoulder pain before her operation.

Another patient complained that if he ate too much he experienced a stitch-like pain in the left supraclavicular region. There were no other complaints of any sort. All appeared to be in excellent health.

With regard to the incision, 4 were in the upper midline and all of these were firmly healed. One had a right-angled extension across the left upper rectus muscles, which was strongly united. Seven were upper left paramedian incisions and three of these had left transverse extensions. There was one incisional hernia among these. It involved the vertical component only of the T-shaped cut. There was one oblique left subcostal incision which was firmly healed.

Blood Examination.—None of the twelve patients followed up were anæmic. Siderocytes were sought in all films but none were found.

Four out of twelve had a slight but quite definite polymorph leucocytosis with counts of 17,000, 15,000, 13,000, and 11,000. Two were at the upper limit of normal, with counts of 9000 and 9400. In the remaining six the blood-counts were normal. No abnormalities were found in the bleeding time, clotting time, prothrombin content, or capillary resistance test. All platelet counts were normal.

The significance of the tendency to leucocytosis in half of the patients followed up is not clear; their general health was in no way impaired.

Such subjective complaints as were voiced were so few and of so minor a nature that they afford no grounds for altering the belief that removal of the organ is the treatment of choice for ruptured spleen.

SUMMARY

Seventeen cases of ruptured spleen treated by splenectomy are reported. There was 1 death.

The injury may be becoming commoner than in the past. Motor accidents are the commonest single cause.

The injury causing rupture is sometimes, and particularly in children, surprisingly slight.

The spleen is the organ most commonly ruptured in non-penetrating abdominal injuries.

It is unusual for any other organ to be injured with the spleen. If there is an associated injury it is most frequently a fracture of the left lower ribs and, after that, damage to the left kidney.

Diagnosis is usually simple, but the clinical picture may be very variable. Cases of slow or delayed hæmorrhage present the most difficult diagnostic problem.

The diagnostic value of various clinical features is discussed. Pain referred to the left shoulder is the most valuable single sign.

Ballance's sign is of negligible diagnostic value.

Plain X-ray examination of the abdomen showing depression of the splenic flexure of the colon by the perisplenic hæmatoma may be of assistance in doubtful cases.

Splenectomy is the treatment of choice. Preoperative measures include blood transfusion where necessary, passage of a stomach tube, and examination of the urine for red blood-cells.

An upper midline incision with, if necessary, an extension across the left rectus muscle is recommended.

In carrying out the splenectomy it may be desirable to reverse the usual order of events, dividing first the gastrosplenic ligament, then the main splenic vessels, and the lienorenal ligament last.

In the post-operative period special attention should be paid to ensuring adequate ventilation of the lung bases. Pleural effusions should be watched for and aspirated.

There was only one serious immediate post-operative complication in this series, a left anterior subphrenic abscess.

Late follow-up has revealed no impairment of general health. Specific complaints have been few.

One-third of the twelve cases followed up showed a slight but definite polymorphonuclear leucocytosis.

I wish to acknowledge my indebtedness to Mr. V. C. Pennell for his criticism and advice in the preparation of this paper; the various registrars at Addenbrooke's Hospital, who operated on 9 of the cases in this series; to Mr. Sidney Riddiough, who was in charge of the case in Huntingdon Hospital; and to Dr. John Marks for the hæmatological investigation of the cases followed up.

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STRANGULATED DIAPHRAGMATIC HERNIA WITH TORSION OF THE STOMACH

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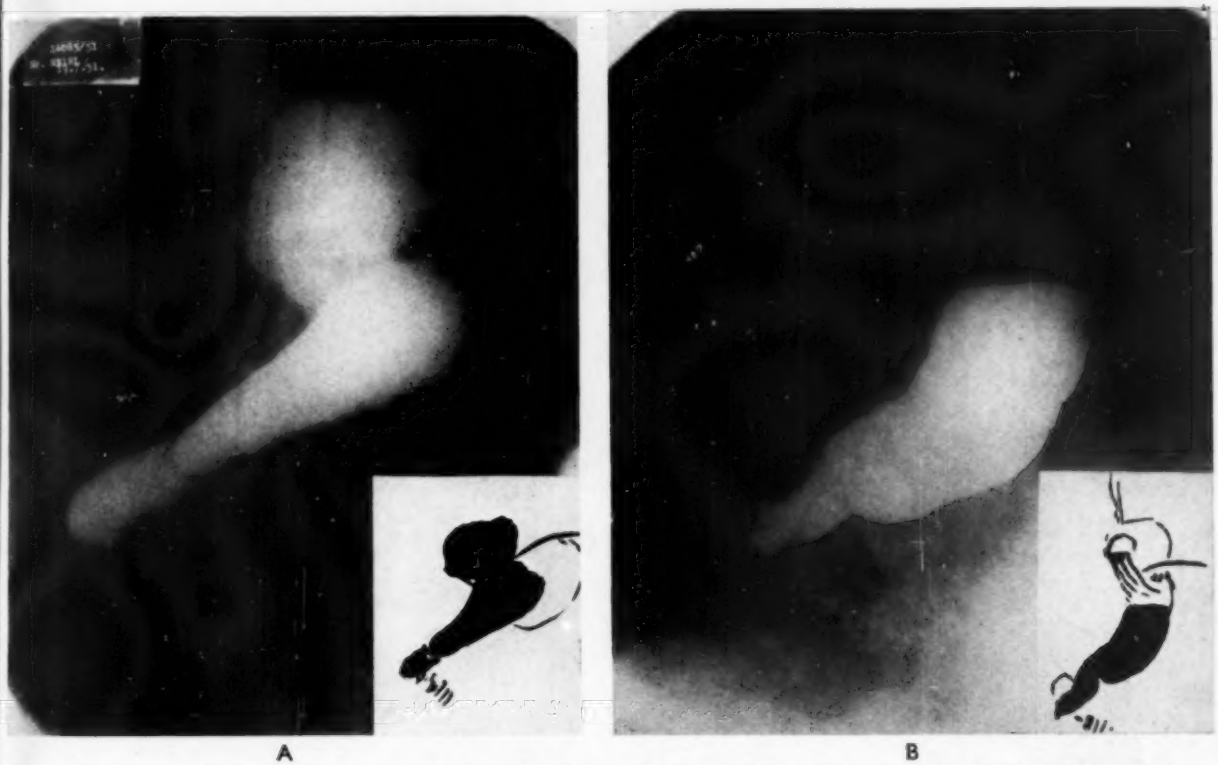
Though strangulation is a common occurrence in most forms of hernia it is rare in herniation through the diaphragm. When it does occur it is more likely to be found in traumatic varieties than in the œsophageal hiatus group. Carter and Giuseffi (1948) collected 43 cases from the literature since 1798 and found that 34 of these occurred through traumatic deficiencies, 4 were congenital and 5 of unknown origin. Further instances have been recorded by Denis (1934), by Weeder (1935), by Deaner, McMenemey, and Smith (1943), by Gardiner (1944), by Shields (1947), by Codounis (1949), by Pearson, Pillsbury, and McCallum (1950), by Dalgaard (1952); in the case of Moore (1950), and Radley and Goldsmith (1949) in addition to strangulation the stomach was also perforated in the area of constriction.



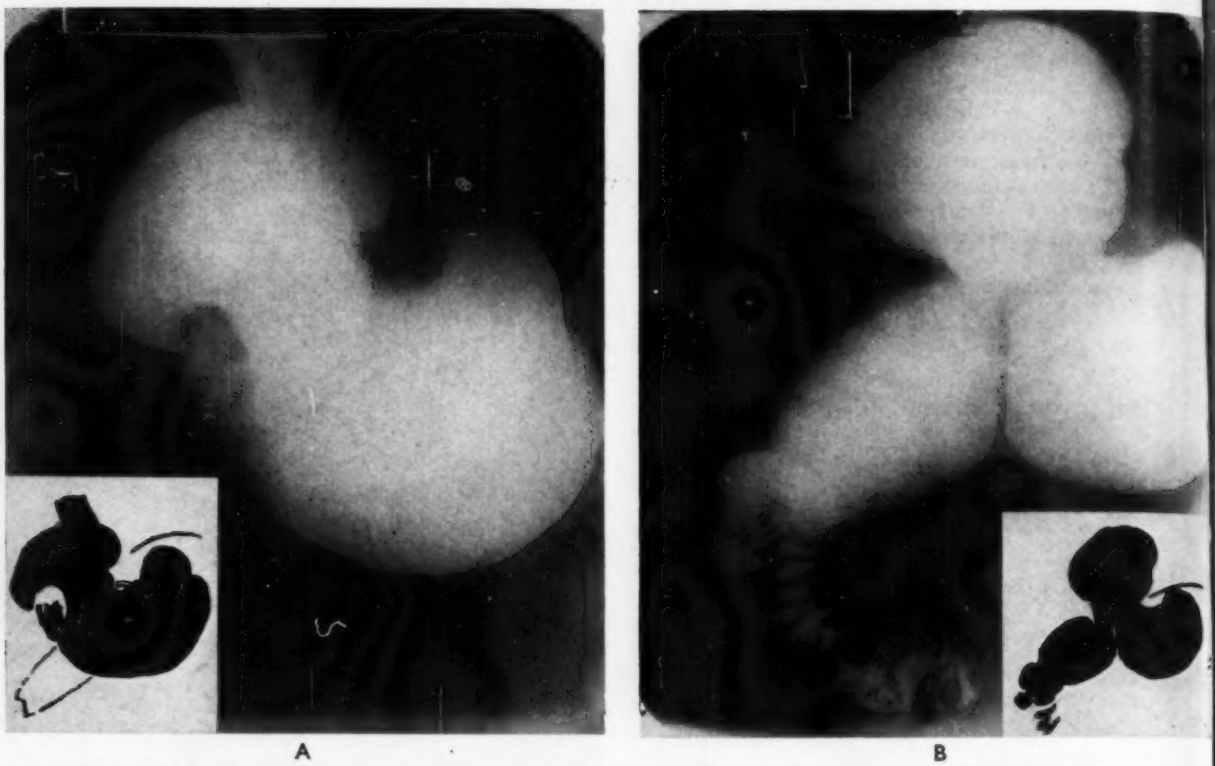
A B

Fig. 323.—Radiographs taken 1951. A, Patient lying down. Torsion marked. Intrathoracic loculus filled. B, Patient standing. Hernia still present but loculus emptied and torsion largely reduced.

The present article records a case in which strangulation occurred through the œsophageal hiatus and was associated with torsion in the long axis of the stomach. The patient was operated on and made a successful recovery.

When a diaphragmatic hernia is strangulated the condition constitutes a major catastrophe. The mortality in patients who are not operated on approaches 90 per cent, and of the cases recorded above only those of Denis, of Gardiner, and of Pearson, Pillsbury, and McCallum survived. The danger of the condition lies in the difficulty of early diagnosis and the rapid progress of symptoms after a comparatively insidious onset. "Acute dysphagia with agonizing pain resembling angina pectoris", as quoted by Wells (1953), is not an early symptom. The onset is marked by vomiting and pain in the epigastrium radiating to the chest and left shoulder; hiccup and sudden shortness of breath may occur, but none of these is usually severe enough to draw attention to the impending disaster. Abdominal signs are minimal when only the stomach is strangulated, though there will be the classical signs of intestinal obstruction if the small gut or colon is involved. In general, the picture is more suggestive of a chest condition than an abdominal one and rupture of the œsophagus gives somewhat similar features. Within a short time the impacted and strangulated intrathoracic bulb distends and at the same time a blood-stained effusion develops within the pleural sac. This may give rise to diminished movement of the chest and hyperresonance on percussion until the signs of effusion obscure the tympanitic note. The mediastinum is often displaced by the pressure and difficulty in breathing is constant. The general condition deteriorates rapidly and efforts at retching and acute epigastric discomfort become obvious. Severe shock and prostration are associated with the increasing distress and shortness of breath.

If radiological examination is possible the air-containing loculus may be visualized and even confused with a tension cyst, a hæmothorax, or a high diaphragm. The presence of a large effusion may obscure the loculus but only if it is excessive in volume. Diagnosis is always difficult unless the



A B

FIG. 324.—Pre-operative radiographs. A, Hernia and fundus grossly distended and obstructed. Free communication between fundus and hernia, but no communication with antral part of stomach. B, Obstruction to antrum freed. Stomach appears as 3 sacs, the fundus and the antrum with the hernia pouch above.

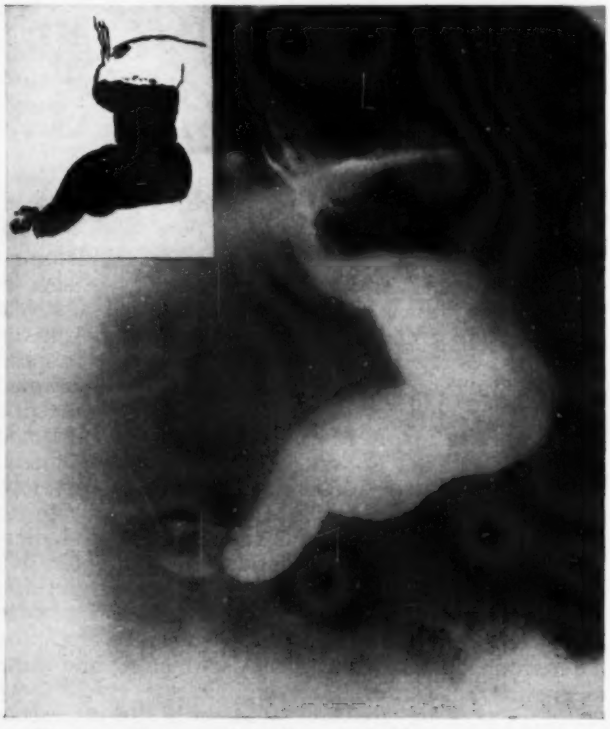


FIG. 325.—Post-operative radiograph showing normal stomach outlined with no torsion and no herniation.

possibility of an intrathoracic loculus of stomach is considered. The most satisfactory clue is given by a definite history of diaphragmatic hernia, particularly if there has been radiological confirmation before operation. If the onset is not as acute or as dramatic as described it may be possible to carry out radiological examination and to find the obstruction before the patient's condition deteriorates.

In the present case record the diagnosis was comparatively straightforward because the hernia had been recognized for a number of years.

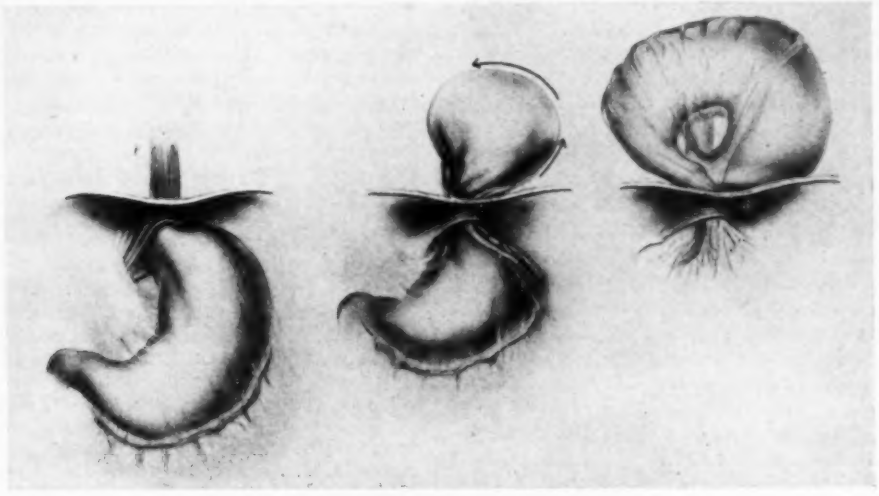
CASE RECORD

A heavily built man, aged 62, complained in September, 1950, of increasing digestive discomfort for two weeks. He had epigastric pain for some hours after meals; this was relieved by further food intake. There was no belching, heartburn, or regurgitation and no previous history of indigestion. The only relevant previous history was that he had had a pharyngeal pouch removed in 1948.

A barium meal revealed an œsophageal hiatus hernia and the condition was treated successfully with two-hourly feeds, atropine, and alkalis. He remained well for 4 years with only occasional discomfort and lived an active life.

On June 29, 1954, he woke early with severe colic in the epigastrium, the pain spread to the left chest and he vomited repeatedly. He had had a heavy meal the night before. On examination he did not appear distressed; pulse 70, temperature 98·6°, respirations 18. There was slight epigastric tenderness on palpation but no distension

or guarding. He was given sedative and seen again in the evening. He had vomited several times during the day and the epigastric pain continued. Examination of the chest showed indefinite dullness at the left base, temperature had risen to 99°, and the pulse to 80. The following morning there was sudden improvement, the pain subsided and the vomiting ceased, but during the night pain and vomiting started again and a barium meal was carried out which showed impaction of part of the stomach above the diaphragm. During the course of the examination the obstruction to barium in the stomach gave way and barium was seen to pass into the duodenum. The following day he was operated on.



A

B

FIG. 326.—Volvulus of stomach with hernia. A, Shows mechanism by which an inverted stomach is produced. B, Demonstrates mechanism of long axis torsion followed by hernia of the body of the stomach as the present case records.

RADIOLOGICAL FINDINGS.—The diaphragmatic hernia when first examined in 1950 was already of moderate size. In the recumbent position (*Fig.* 323 A) a large part of the stomach was above the diaphragm. The intra-abdominal stomach was rotated about the cardia-pyloric axis so that the greater curvature was upwards and the lesser curvature down. The part of the stomach which had herniated consisted of a portion of the greater curvature below the fundus and there were free communications between the fundus portion, the herniated loculus, and the antral part of the stomach. In the erect position (*Fig.* 323 B) the weight of barium dragged the hernia from the chest and the stomach assumed a normal shape as the rotation disappeared. These findings were unchanged at an examination carried out in July, 1951.

The radiographs taken on July 1, 1954, at the time of the strangulation, showed an enormous dilatation of stomach—one part lying above the diaphragm and the other consisting of the fundus and neighbouring part of the body of the stomach (*Fig.* 324 A). These sacs communicated freely, but there was no passage of barium into the antral end of the stomach. At the end of three-quarters of an hour the obstruction was slightly relieved and the barium passed through the pylorus in small quantities. A duodenal diverticulum was also noted (*Fig.* 324 B).

AT OPERATION (July 2, 1954).—The approach was a left lateral thoracotomy through the bed of the 7th rib. There was free fluid, slightly blood stained, in the pleural cavity. On retracting the lung there was a large mass of stomach about the size of a grape-fruit emerging through the œsophageal hiatus and firmly impacted. The vessels were engorged and purple and the surface of the stomach congested. The diaphragm was incised antero-posteriorly in the region of the central tendon and the abdomen opened. The intra-thoracic portion of the stomach consisted of the body of the stomach which was placed so that curvatures were reversed. The remainder of the stomach within the abdomen was twisted on its long axis except for the part close to the œsophagus and the adjacent fundus (*Fig.* 326 B). By gentle manipulation, after removal of considerable masses of adherent omental fat, the hernia was reduced into the abdomen. Freeing of infra-diaphragmatic adhesions from the greater curvature allowed the stomach to take up its normal position. The hiatal orifice was closed by placing several stout sutures between the separated crural fibres posterior to the œsophagus which was of normal length. The œsophageal fibres were then sutured to the hiatal ring to maintain

the position of the lower œsophagus in relation to the diaphragm.

Convalescence was uneventful except for some signs at the left base which cleared quite rapidly. A barium meal carried out four months later showed that there was no evidence of the hiatus and that there was no œsophageal reflux. The stomach was of a high transverse type and there was no suggestion of volvulus of the stomach (*Fig.* 325).

DISCUSSION

Association of gastric torsion or volvulus with diaphragmatic hernia is well known. In 1909 Payer recorded 12 instances among 500 cases of diaphragmatic hernia, and Dalgaard (1952) in a review of 150 cases found hiatus hernia in 22. Similarly, Spriggs and Marxer (1954) found 2 instances of massive herniation in 44 patients with twisting of the stomach.

There are two types of volvulus or torsion that can be recognized: the one, which was present in this case record, consisting of rotation in the long axis of the stomach; the other in which the stomach as it passes into the chest is turned upside down or inverted as the greater curvature 'pays out' into the thorax and lies above the lesser curvature. (*Fig.* 326 A, B.)

Posture plays a considerable part in the development and size of the hernial sac. With the patient erect the weight of the gastric contents minimizes the effects of the herniation and, as in the present case, may even relieve a partial obstruction. If, however, the patient is lying down and the stomach or sac is overloaded more and more of the rotated stomach is forced into the chest where the risk of impaction and later strangulation is a possibility. In this case the volvulus and impaction were intermittent and strangulation only occurred on the occasion that led to operation.

It is worth considering how posture can best be used in helping to relieve a crisis in patients who may have torsion of the stomach, but if a case has developed into one of strangulation then there is nothing other than surgery that should be considered.

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EARLY CARCINOMATOUS CHANGES IN THE STOMACH

BY J. BAMFORTH

IMPERIAL CANCER RESEARCH FUND LABORATORIES, ROYAL COLLEGE OF SURGEONS OF ENGLAND

THE early beginnings of carcinoma of the stomach may occur in two forms, the polypoid and the non-polypoid, the latter being very liable to ulcerate and frequently found in the prepyloric region. In this paper 5 cases are presented illustrating the very early changes and subsequent development which may occur in carcinoma of the non-polypoid form. All five cases were submitted to operation for chronic peptic ulcer. On subsequent examination of the stomach macroscopically chronic peptic ulcer was found in every case. In one instance only (*Case* 3) was anything unusual noted and in none was malignant disease recognisable.

CASE REPORTS

Case 1.—No clinical details are available. The specimen, obtained some years before the last war, is that of a typical chronic ulcer near the pylorus.

Histological examination shows two foci of early malignant change situated at a distance of 5 mm. from each other. In these foci, one of which is illustrated in *Fig.* 327, there is a proliferation of small spheroidal cells closely packed together occupying almost the whole of the mucous membrane. One or two of the deep glands remain. There is no sign of invasion of these spheroidal cells beyond the muscularis mucosæ. In this case there is an early carcinomatous change arising in the mucous membrane from two independent foci. It is interesting to note that the type of neoplasm, small spheroidal-cell carcinoma, is determined at such an early stage.

Case 2.—Except for a long history of stomach trouble no clinical details are available. Gastrectomy for chronic gastric ulcer in 1950.

Histological examination shows the typical appearances of a chronic peptic ulcer in the pyloric region. In the mucous membrane near one edge of the ulcer a small group of gastric glands shows a definitely abnormal appearance and stands out in marked contrast to the glands on either side. There is atypical proliferation of the glandular cells which are hyperchromatic and show variations in shape and size. The cells tend to be crowded together and several mitoses are present. There is no sign of invasion of the deeper tissues (*Figs.* 328, 329). It is considered that these changes represent what may be a very early carcinomatous change.

Case 3.—This specimen is from a woman, aged 55, with a nine years' history of stomach trouble. The stomach, removed at operation in November, 1953, showed a circular ulcer 6 cm. from the pylorus. The ulcer measured 15 cm. in diameter and its floor was covered with yellow slough. Adjacent to it on one side there was roughening and dark brown discoloration of the mucous membrane.

Histological examination shows the typical appearances of a chronic peptic ulcer. In the superficial two-thirds of the mucous membrane, extending for a distance of

0·5 cm. from the edge of the ulcer, striking changes are found. There is atypical proliferation of the glandular epithelial cells which are closely applied together, forming small irregular solid masses between which many leucocytes are present. The proliferated epithelial cells are irregular in shape and size but do not stain intensely. Occasional mitoses are present. Some of the small clear glands of the pylorus remain intact above the muscularis mucosæ—these changes are better seen a little farther away from the ulcer edge. There is then an abrupt change to normal mucous membrane (*Fig.* 330). Further from the ulcer, foci of atypical changes occurring at intervals are found in the deeper glands. The clear cells of the pyloric glands have been replaced by a much more prominent and deeply staining epithelium in which numerous goblet cells occur, as found in the small intestine. Section through the roughened and dark-brown mucous membrane noted on gross examination shows exactly similar changes to those described as occurring in the mucous membrane at the edge of the ulcer. The deep glands of the gastric mucosa are shown continuously, and it is clear that these atypical proliferative changes are confined to the superficial part of the mucous membrane. There is no invasion of the muscularis mucosæ (*Fig.* 331).

It is considered that this case shows an early carcinoma of multifocal origin arising from the superficial parts of the glands.

Case 4.—A man, aged 52, with seven years' history of gastric trouble. Partial gastrectomy was performed in April, 1952. The patient is alive and well (April, 1955). On the lesser curvature was a small ulcer, 0·5 cm. in diameter, and 2 cm. away from it, and to one side of the lesser curvature was another shallow ulcer about 1 cm. in diameter. Section through the first ulcer showed a complete breach of the mucous membrane, the floor being covered by greyish material. There was no thickening of the stomach wall. Section through the second ulcer appeared to show a thin but intact mucous membrane. Microscopical sections were prepared one from each ulcer and one from a piece of apparently normal stomach.

Histological examination of the first ulcer shows the typical appearances of a chronic peptic ulcer. The mucous membrane, present in the section for a distance of 1 cm. on either side of the ulcer, shows active gastritis, many inflammatory cells being present in the stroma. Section of the second ulcer shows that it has been produced by the ulceration of a carcinoma. There is no evidence of a previous chronic peptic ulcer. In the floor of the ulcer the mucous membrane has disappeared. There is a zone of necrosis on the surface subjacent to which islets of columnar-cell carcinoma are present in the submucosa and are seen to be invading the subjacent lymphoid tissue. These islets can also be found for some distance beneath the mucous membrane at the edge of

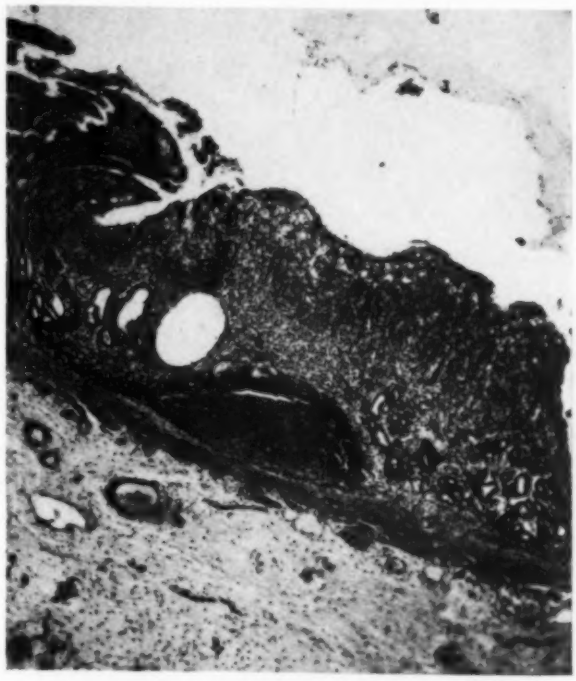

FIG. 327.—*Case* 1. One of two foci of proliferation of small spheroidal cells in the mucous membrane close to the edge of a chronic gastric ulcer. (× 30.)

FIG. 328.—*Case* 2. Atypical proliferation of a small group of pyloric glands near the edge of a chronic ulcer. (× 12.)

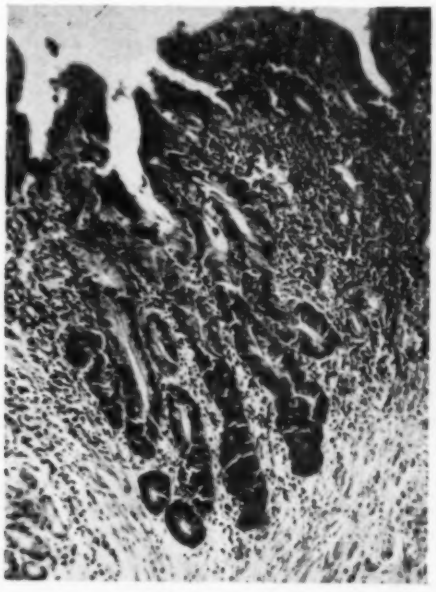

FIG. 329.—*Case* 2. The atypical changes in the glands indicated in *Fig.* 328. (× 82·5.)

the ulcer (*Figs.* 332 and 333 represent continuous tissue). The malignant process is observed to be spreading along the superficial part of the mucous membrane forming small, irregular, solid epithelial masses, but the deep clear glands of the pylorus appear normal. Then this change gives place to a more normal mucosa (*Fig.* 333). Section of apparently normal stomach at some distance from the ulcers shows that early carcinomatous changes are present in the mucosa—a part of this section is illustrated in *Fig.* 334. The irregular nature of the process is indicated by the areas of more normal mucous membrane situated amongst the abnormal tissue. These changes are obvious in the deeper part of the mucous membrane, although also present beneath the surface. The solid, deeply staining, atypical epithelial cords formed from the deeper parts of the glands constitute a striking feature. No invasion beneath the muscularis mucosæ is found.

The fact that these changes were present in what appeared on macroscopical examination to be normal stomach, suggests that there has been an extensive spread of the malignant process in the mucous membrane.

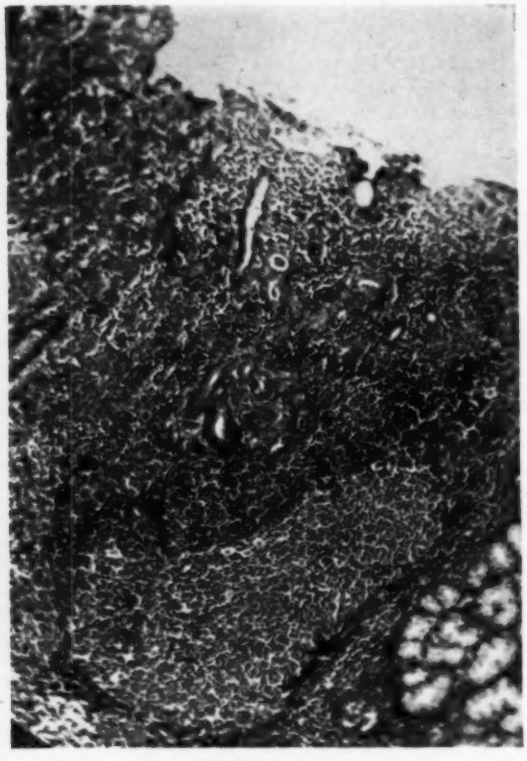

FIG. 330.—*Case* 3. Atypical proliferation in the superficial part of the mucosa continuous with that found at the edge of a chronic ulcer and an abrupt change to normal. (× 60.)

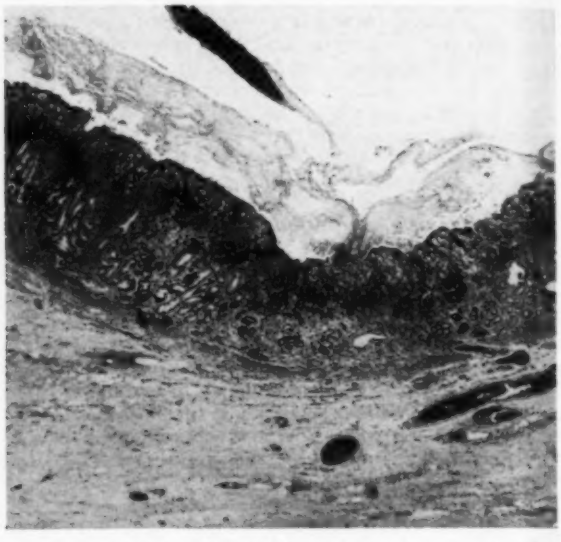

FIG. 331.—*Case* 3. Atypical proliferative changes in the roughened and dark brown mucous membrane. (× 18.)

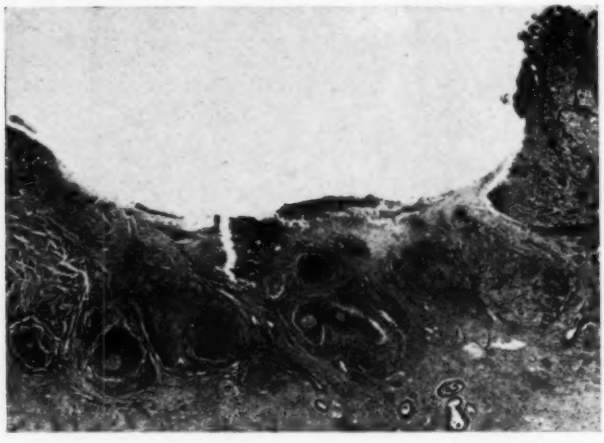

FIG. 332.—*Case* 4. A carcinomatous ulcer with invasion of the submucosa. (× 10·5.)

FIG. 333.—*Case* 4. Spread of the malignant process in the mucous membrane. (× 10·5.)

Case 5.—A woman, aged 71, with a history of gastric trouble for many years. Partial gastrectomy, November, 1953; alive and well, April, 1955. At operation an 'hour-glass' stomach was found and also pyloric stenosis. Two ulcers were present. One, circular in shape with sharply defined edges, measured 22 mm. in diameter. Omental tissue was firmly attached to the outer aspect of this ulcer. The other, oval in shape, was situated close to the pylorus and measured 18 × 12 mm. Its edges were firm and slightly everted; the floor was covered with thin grey slough. Elsewhere the stomach wall and mucosa had a normal appearance. A few glands, the largest measuring 15 mm. in diameter, were palpable in the lesser omentum; these appeared firm and white on section.

Histological examination of the larger ulcer and adjoining tissue show marked inflammatory changes in

the duodenal mucosa. Nearer to the ulcer in the pylorus, the glands, more complex in shape, are considerably increased in number. The glandular epithelium is hyperchromatic and shows many mitotic figures forming in one part small, solid-cell masses. These changes continue with greater or less intensity as far as the edge of the ulcer. At this point there is definite invasion. The glandular hyperplasia. This pattern is retained until the edge of the ulcer, where there is a suden change to a more spheroidal type of cell. The ulcer has been produced by the ulceration of a carcinoma. The malignant tissue extends to the necrotic surface; small irregular masses of cells, partly columnar, partly spheroidal, interspersed with many leucocytes, are seen invading a nodule of

FIG. 334.—*Case* 4. Further changes in the mucosa at some distance from the malignant ulcer. (× 26·25.)

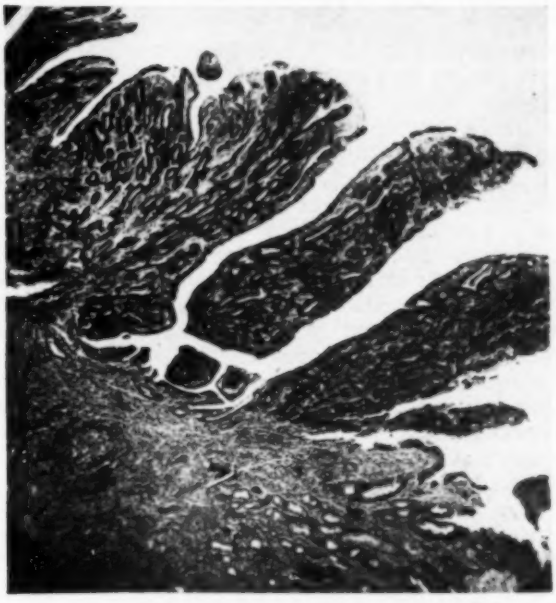

FIG. 335.—*Case* 5. The appearances of papilliferous columnar-cell carcinoma in the mucous membrane. This tissue is directly continuous with that on the left margin of *Fig.* 336. (× 22·5.)

malignant tissue in the mucosa has almost entirely sloughed away, but numerous small islets of carcinoma are scattered throughout the subjacent lymphoid tissue and are just beginning to invade the floor of the ulcer adjacent. The ulcer itself is a typical chronic active

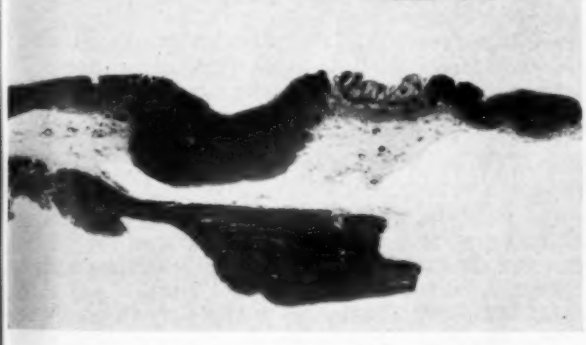

FIG. 336.—*Case* 5. A succession of changes in the mucous membrane—atypical proliferation passing into spheroidal-cell carcinoma with early ulceration and invasion, then a patch of intestinal mucous membrane, and finally more malignant changes in the mucosa. (× 2·5.)

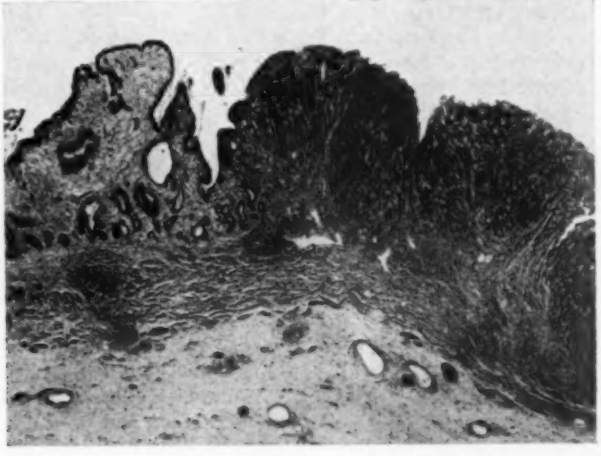

FIG. 337.—*Case* 5. Adenomatous proliferation of the deeper glands in the intestinal mucous membrane, seen in *Fig.* 336, passing gradually into a more malignant process. (× 15.)

peptic ulcer. The mucous membrane on the cardiac side shows inflammatory changes only.

Sections of the wall of the stomach, including the smaller ulcer and tissue on either side, present a series of pictures showing different stages in the carcinomatous process. First a small piece of mucous membrane (illustrated in *Fig.* 335) gives the appearances of a papilliferous columnar-celled adenocarcinoma—this is directly continuous with a series of changes shown by low magnification in *Fig.* 336. In this photograph the mucous membrane on the left of the ulcer shows very atypical lymphoid tissue situated beneath the mucosa but have not penetrated farther into the stomach wall. On the right of the ulcer is an atrophic portion of mucous membrane which resembles that of the small intestine. The glands, few in number, are situated chiefly in the basal portion. The glandular cells are hyperchromatic and in some glands irregular adenomatous proliferation forming bud-like processes projecting into the lumina is found (*Fig.* 337). Then there is another sudden change. The glands are increased in number, become more and more atypical, until solid epithelial cords are formed.

Except in the region of the ulcer no invasion beyond the muscularis mucosæ was found.

Sections from the piece of stomach wall some distance remote from the ulcers appeared normal. The lymph-glands showed chronic inflammatory changes but no evidence of malignancy.

DISCUSSION

The first two cases described here are considered to represent an early non-invasive stage in the development of carcinoma of the stomach of non-polypoid form. This lesion, also described as carcinoma in situ, is acknowledged by Mallory (1940) and described by him in 4 cases which were associated with peptic ulceration. Newcomb (1932) described, amongst several cases of carcinoma following peptic ulcer, one in which the cytological criteria of malignancy were present, but it was only after further blocks had been cut that infiltration of lymphatics was demonstrated. Identical cytological changes, however, are found in these early cases whether invasion is determined or not. Further, the presence of plaques of carcinoma in situ in continuity with a frank invasive carcinoma and extending for some distance in the mucous membrane has been described by other authors (Collins and Gall, 1952) and was a marked feature in *Case* 4 of this paper. The length of time required for a non-invasive carcinoma of the stomach to become invasive is difficult to determine, but analogy with other organs, for example the cervix uteri, would suggest that a considerable period may elapse. The origin of gastric carcinoma from separate independent foci as occurs in the skin and other organs is shown in the cases described here and has been noted by previous authors (Ewing, 1936; Collins and Gall, 1952).

Cain, Jordon, Comfort, and Gray (1952), in a review of 414 cases of medically treated gastric ulcer followed up for a period of five years, found that 4·9 per cent had developed gastric carcinoma and consider that gastric ulcer or the mucosa of the stomach diseased by gastric ulcer is a precursor of cancer of the stomach.

In a comparison between 262 cases of chronic gastric ulcer treated medically and 254 cases treated by surgery during the years 1940 to 1946 inclusive, Swynnerton and Tanner (1953) found, at the end of 1952, that 61 cases in the medical, and 56 in the surgical series had died since their initial stay in hospital. Of those, 15 in the medical and 11 in the surgical group developed carcinoma; in 10 cases (6 and 4 respectively) the primary growth was probably in the stomach. In 3 of the surgical cases histological examination showed no evidence of malignancy. In 2, and possibly 3, of the cases the removal of the large portion of the stomach did not prevent the subsequent development of a carcinoma. The authors state that there is insufficient evidence to label them ulcer-cancers and conclude that if an association between ulcer and cancer exists, it is due to a preference of both for the same type of degenerate mucosa. Such evidence as can be obtained from a study of these five cases would appear to support this view. The tendency for this type of neoplasm to involve an appreciable area of gastric mucosa necessitates a more extensive investigation of stomachs removed for gastric ulcer if a more definite answer to this question is to be given.

Mr. Tanner was able to obtain the sections from three of the cases of benign gastric ulcer which were treated by surgery and which subsequently died of carcinoma of the stomach. On re-examination, one showed malignant changes in a previously simple ulcer; the other two showed the early superficial malignant changes in the mucosa as described in this paper.

SUMMARY

Five cases of early non-polypoid carcinoma of the stomach discovered fortuitously, each associated with a chronic peptic ulcer, are presented. All were unrecognized on gross examination of the stomach.

The condition may arise as a non-invasive carcinoma confined to the mucous membrane.

The multifocal origin of gastric carcinoma is shown.

Various phases in the malignant process may be observed and the type of carcinoma determined at a very early stage. The carcinoma may arise quite close to an ulcer or at a distance.

A more extensive investigation of the stomach removed by gastrectomy for chronic peptic ulcer might prove of advantage in the question of ulcer-cancer.

These cases were operated on at St. Thomas's Hospital and I wish to thank Dr. J. L. Pinniger for some of the material and for the kindly interest he has taken in this paper.

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TOTAL COLECTOMY AND ANTERIOR RESECTION OF THE RECTUM WITH ILEORECTAL ANASTOMOSIS

A ONE-STAGE OPERATION FOR ULCERATIVE COLITIS

By RONALD W. RAVEN, O.B.E., T.D., London

There has been an awakening in our interest concerning ulcerative colitis during the present decade which has resulted in a better understanding of various aspects of this difficult problem. We still have no clear conception of its aetiology and more intensive work is necessary. Bacteriological studies of the colon have not provided the answer and the possible relationship with dysentery was rejected. There is no definite evidence that food sensitivity and allergy play a part; psychopathological states and hormonal disturbances require further consideration.

The pathological changes in the bowel are clearly defined. They seem to be caused by an inflammatory disease of a non-specific nature which commences in the mucous membrane of a segment of the colon. The process spreads through all the coats of the bowel as well as along its length so that eventually the whole of the colon and rectum may be affected. Any part of the bowel can be involved initially; in some the distal colon and upper rectum are implicated, in others the right colon, and it can spread into the terminal ileum.

The complications are numerous, some are serious and may be multiple in the patient. They are important from the surgical viewpoint and include polyp formation, strictures of the bowel, development of carcinoma, skin lesions, degeneration of viscera, eye lesions, infective arthritis, bacterial endocarditis, mesenteric thrombosis, and serious hæmorrhage.

Treatment.—Developments have occurred in the management of these patients and it is agreed, in the absence of complications constituting an immediate threat to life, that they should be treated conservatively in the first place, for some improvement is usually achieved even in those who are very ill.

SURGICAL TREATMENT

The indications for operation are now defined as follows: (1) Patients with severe disease described as fulminating colitis. (2) Patients with exsanguinating bowel hæmorrhage. (3) Patients unresponsive to conservative treatment, especially with relapses and a long history. (4) Patients with complications.

Patients in group 1 are given supportive treatment and if good improvement is achieved within three days an ileostomy is instituted. Those in group 2 require supportive treatment, and a total colectomy with an ileostomy is done as a one-stage operation. There has been much discussion and argument regarding the value of the various surgical procedures for patients in group 3 particularly, although this applies in the main to those in other groups. Regarding those with complications the operative procedure will vary with the type which is present and it is not my purpose to discuss this. The main object of this paper is to describe an operation which I have found valuable in a small group of patients for whom surgical treatment was essential. It is pointed out that a small percentage only of patients with ulcerative colitis requires this radical operation and the view is put forward that it is the best procedure for them.

Total Colectomy and Anterior Resection of the Rectum with Ileorectal Anastomosis.—When the whole of the colon and majority of the rectum is affected and surgical treatment is desirable it is clear that the diseased part of the bowel should be removed. It is greatly to the benefit of the patient if the continuity of the alimentary tract is restored and normal defæcation established. If this can be achieved with safety as a one-stage operation its value

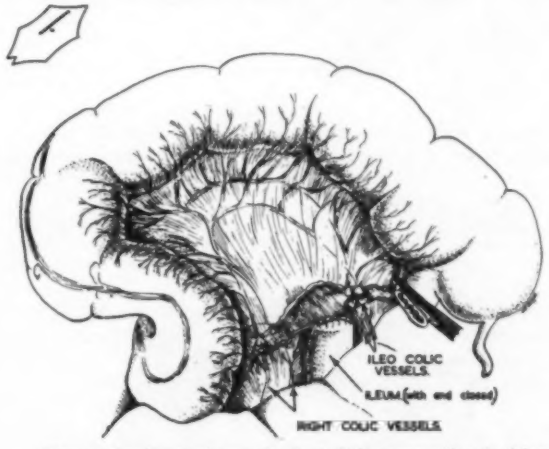

Fig. 338.—Inset shows the long left paramedian incision commencing at the pubes with the patient in the Trendelenburg position. The main drawing shows the ileum divided and the proximal end closed. The ileocolic and right colic blood-vessels have been ligated and divided.

is obvious. I wish to make it clear that the patients' ability to undergo this operation is always considered carefully when the clinical and laboratory investigations are available.

Pre-operative Care.—The routine treatment before a major operation is carried out and intestinal chemotherapy is instituted.

Technique.—The abdomen is opened through a long left paramedian incision 7 in. long which commences at the pubis. The contents are examined and the extent of the disease in the colon is determined; any involvement of the terminal ileum is also noted. The condition of the liver is investigated and in several patients with liver damage I performed a biopsy.

Division of Ileum.—When normal this is divided 12 in. from the ileocæcal valve; in other cases the section is made wide of the disease. The proximal end of the ileum is closed with a double layer of sutures of catgut.

Mobilization of the Right Colon.—The peritoneum is divided along the outer side of the cæcum and ascending colon up to the hepatic flexure and the colon is mobilized. The branches of the ileocolic, right colic, and middle colic blood-vessels are ligated and the mesentery is divided (*Fig.* 338).

Mobilization of the Transverse Colon.—The great omentum is separated off the upper border of the transverse colon, and the hepatic and splenic flexures are mobilized. The branches of the middle colic blood vessels are ligated and the transverse mesocolon is divided.

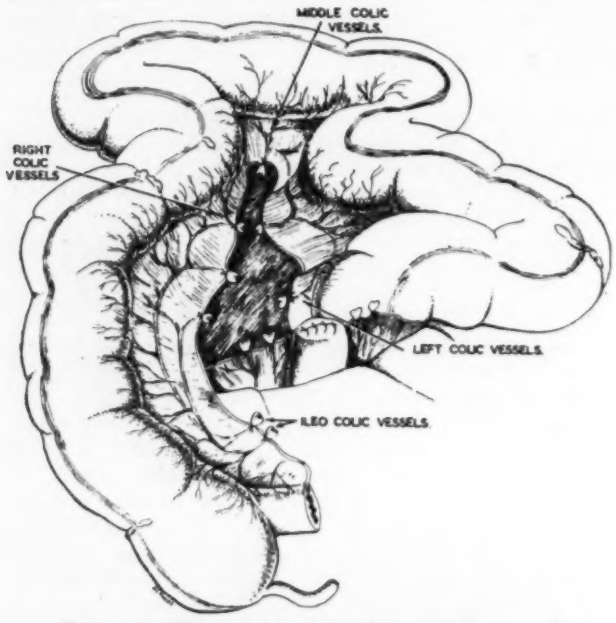

FIG. 339.—The cæcum, ascending, transverse, and descending parts of the colon are mobilized; the middle and left colic blood-vessels have been ligated and divided.

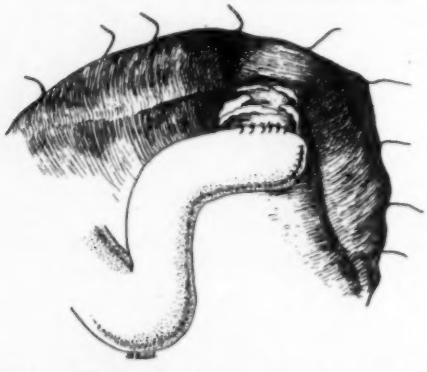

FIG. 341.—The colon and upper two-thirds of the rectum have been removed and the upper end of the rectum closed. The ileorectal anastomosis has been performed, the side of the ileum being joined with the antero-lateral wall of the rectum.

Mobilization of the Distal Colon.—The peritoneum on the lateral aspect of the bowel is divided from the splenic flexure to the pelvic colon and the colon is mobilized. The branches of the left colic and the sigmoid blood-vessels are ligated and the mesentery is divided (*Fig.* 339).

The patient is now placed in a medium Trendelenburg position.

Mobilization of the Pelvic Colon and Upper Three-quarters of the Rectum.—The peritoneum on the lateral aspects of the pelvic colon and upper rectum is incised and the incisions are carried forward to meet in front of the rectum behind the urinary bladder in the male and vagina in the female. The superior hæmorrhoidal blood-vessels are ligated and divided. The reflections of the pelvic mesocolon to the sacrum are divided and the rectum is mobilized posteriorly in its upper three-quarters. The lateral ligaments are then divided and the middle hæmorrhoidal vessels may require ligature. The anterior aspect of the rectum is mobilized as far as the base

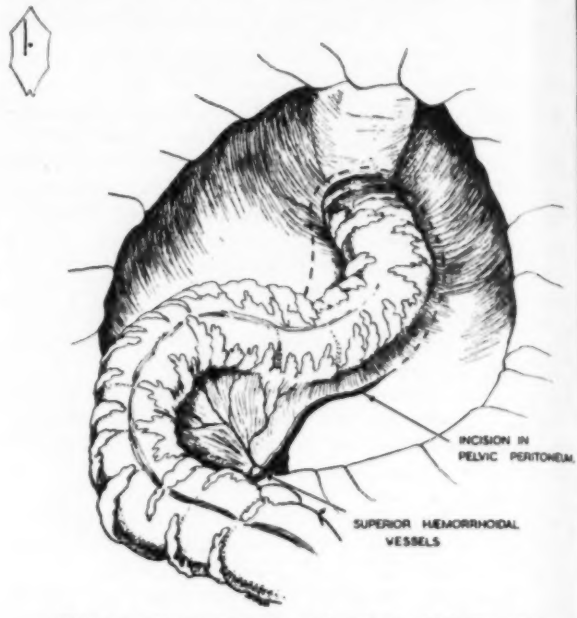

FIG. 340.—Inset shows the patient in the high Trendelenburg position. The pelvic peritoneum is incised on the lateral aspects of the pelvic colon and rectum to permit their mobilization. The sigmoid and superior hæmorrhoidal blood-vessels have been ligated and divided.

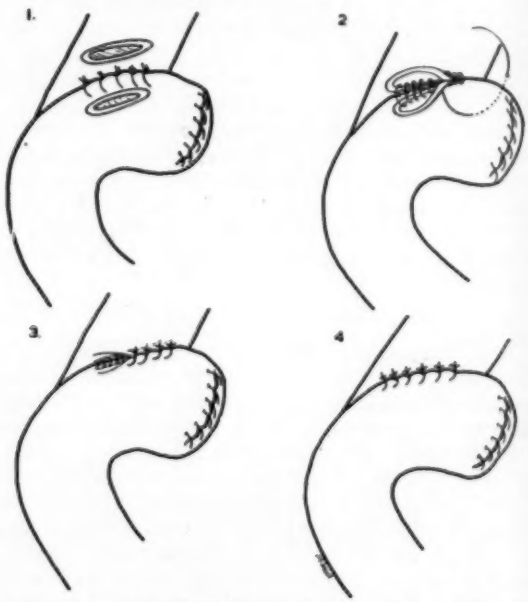

FIG. 342.—The technique of the ileorectal anastomosis. 1, Posterior layer of interrupted thread sutures through seromuscular coats of the ileum and the muscular coat of the rectum. 2, The posterior continuous catgut suture through all the coats of the ileum and rectum. The anterior layer of suturing has commenced. 3, The anterior layer of continuous catgut suturing has been completed. The anterior layer of interrupted thread sutures through the seromuscular coats of the ileum and the muscular coat of the rectum has commenced. 4, The anterior layer of interrupted sutures is finished and the ileorectal anastomosis is made.

of the prostate in males and to the middle of the vagina in females (*Fig.* 340).

Division of the Rectum.—The rectum is divided transversely at the junction of the upper two-thirds and lower third. The upper end of the rectum is then closed with a double layer of continuous sutures of catgut (*Fig.* 341).

The Ileorectal Anastomosis.—The side of the ileum is anastomosed to the anterolateral aspect of the rectum (*Fig.* 342). The anastomosis is begun by inserting a posterior layer of interrupted sutures of thread uniting the sero-muscular coat of the ileum to the muscular coat of the rectum (1). An incision 1¼ in. long is then made in the rectum and ileum and a posterior continuous suture of catgut is inserted through all layers (2). It is continued along the anterior wall of the anastomosis (3), and finally interrupted sutures of thread are inserted through the sero-muscular coat of the ileum and the muscular coat of the rectum (4).

The pelvic peritoneum is not reconstructed. The mesentery is sutured to the posterior abdominal wall, a rubber drainage-tube is inserted down to the anastomosis and brought out through a lateral stab incision. The abdominal wound is then closed.

Post-operative Care.—This is carried out as for any major surgical operation. The bowels are usually opened on the fourth or fifth post-operative day and are usually very active for a week or two. Probanthine (1 tab. t.d.s.) is sometimes efficacious in diminishing the frequency of defæcation, and charcoal biscuits and codeine phosphate (gr. ¼ 4-hourly) are also helpful. The drainage-tube is removed when the bowels are working well about the twelfth day. The patient's diet is gradually built up to normal.

CASE REPORTS

Case 1.—Female, aged 37, married, was seen on Feb. 16, 1953, complaining of chronic diarrhœa.

HISTORY.—She was well until 12 years ago when she had 'influenza for 24 hours' with diarrhœa. The latter persisted and she had 8 bowel actions a day and several at night. Nine months later blood was passed with the stools and she was admitted for 5 months to another hospital and treated conservatively without improvement. She became worse and had 18 bowel actions in 24 hours and was admitted to another hospital for 3 months where conservative treatment was given. Nine years ago she had her second child and improved after this, the number of bowel actions being reduced to 8 a day, sometimes with blood. A remission followed which lasted for 2 years. The symptoms again recurred and alternated with remissions. At present she has 8 bowel actions a day and none at night; a lot of blood is present in the stools and a good deal of abdominal pain low in the epigastrium is experienced. She has lost strength and 1 stone in weight during the past year.

ON EXAMINATION.—General nutritional state is satisfactory. Abdomen—the liver is enlarged 3 in. below the right costal margin, surface is smooth, and the edge is sharp. Tenderness over the pelvic colon.

Sigmoidoscopy.—Granular mucous membrane with excess mucus and blood present, superficial ulceration and polyps at 13 cm. from the anal orifice and the bowel narrows in this situation and will not distend.

Radiological Examination after a Barium Enema.—Showed marked procto-colitis affecting the whole colon and inflammatory changes in the terminal ileum. Immediate evacuation was limited and a considerable residue remained at 4 hours.

Hæmoglobin 90 per cent; R.B.C. 3,960,000 per c.mm.; W.B.C. 7200 per c.mm.; blood-urea 20 mg. per cent. Liver function tests: thymol turbidity 5 units; thymol flocculation negative; serum colloidal gold 1; zinc sulphate 6 units; ammonium sulphate 0 units; serum alkaline phosphate 59 units; serum bilirubin—direct 0·5 mg. per cent, indirect 0·3 mg. per cent, total 0·8 mg. per cent. Prothrombin time 15 seconds (control normal 15 seconds).

Rectal biopsy—a fragment of rectal mucosa and submucosa showing chronic inflammation of non-specific type compatible with the diagnosis of ulcerative colitis.

It was considered that the patient had active cirrhosis of the liver in association with chronic ulcerative colitis; she was treated conservatively, given a high calorie, high protein, low residue diet, and kept under observation.

On Nov. 5, 1953, patient was re-admitted as her general condition was deteriorating. She had frequent bowel actions, minimum 8 during the day and 4 during the night with bright red blood and mucus. The liver function tests showed slight deterioration. It was decided that surgical treatment was necessary.

AT OPERATION.—Nov. 16. Total colectomy and anterior resection of rectum with immediate ileorectal anastomosis; liver biopsy performed. Patient made a good recovery.

DESCRIPTION OF SPECIMENS.—

Liver Biopsy.—Shows a multilobular fine cirrhosis with some regeneration of bile canaliculi. Multilobular cirrhosis.

Terminal Ileum, Colon, and Part of Rectum.—Advanced thinning of the bowel wall with ragged ulceration and fibrous replacement. Towards the distal end of the bowel there is increased fibrosis and narrowing.

Histology.—All areas examined show flattening and atrophy of the mucosa with loss of function and occasional shallow ulceration. There is considerable lymphoid proliferation in the submucosa and some fibrosis in the muscle wall. No evidence of malignancy. The appearances are those of ulcerative colitis.

FOLLOW-UP.—The patient made excellent progress, her general condition improved steadily and she gained weight. On Feb. 18, 1954, a rectal biopsy shows intact mucosa with very markedly active goblet cells. The mucosa is infiltrated with round cells to a slight degree but in a manner which can only be regarded as very slightly abnormal. The submucosa and muscularis appears normal. Patient was seen on Aug. 16, when she felt well, gained 1 stone 5 lb., and had 4 or 5 bowel actions a day, none by night. The residual rectum appeared normal.

Liver function tests (Aug. 19): Serum bilirubin—direct 0·7 mg. per cent, indirect 1·5 mg. per cent, total 2·2 mg. per cent; serum alkaline phosphatase 31 units; thymol turbidity 5 units; thymol flocculation 2+; serum colloidal gold 1+; zinc sulphate 6 units; ammonium sulphate 3 units; blood-urea 23 mg. per cent; serum proteins—albumin 4·92 g. per cent, globulin 2·72 g. per cent, total 7·64 g. per cent. Non-protein nitrogen 20 mg. per cent.

On Nov. 15, patient was very well, she has 4 or 5 bowel actions a day, none by night and no bleeding per rectum.

Case 2.—Female, aged 55, single, was seen on Aug. 18, 1947, complaining of chronic diarrhœa.

HISTORY.—Twenty-seven years ago patient developed a mucus rectal discharge when living in New Zealand and was treated conservatively for several years. On returning to England she was better. Sixteen years ago a relapse occurred and these relapses persisted. Recently she experienced a severe attack with diarrhœa and general weakness but this responded to conservative treatment. Her symptoms returned when she went back to work. She was kept under observation.

ON EXAMINATION.—General nutritional state is satisfactory. Abdomen—some tenderness in left iliac fossa and lumbar regions. Rectal examination—tenderness and blood present.

Sigmoidoscopy (Oct. 27, 1952).—Mucous membrane of the rectum is friable and bleeds easily, the changes are worse in the upper rectum; normal distensibility. In July, 1953, she had 15 bowel actions a day and her symptoms continued to be so severe that operation was advised and she was admitted for surgical treatment on Jan. 23, 1954.

Rectal Biopsy.—Shows mucosa within normal limits. Hb—81 per cent. Prothrombin time—14 seconds (normal control 14 seconds).

Radiological Examination of the Colon after a Barium Enema.—There is marked procto-colitis affecting the distal half of the colon; evacuation was satisfactory.

Sigmoidoscopy.—Jan. 25, 1954. The mucosa of the rectum is inflamed; there is narrowing at 15 cm. and the condition of the bowel above is much worse than previously. Blood-stained liquid fæces are present.

AT OPERATION.—Feb. 2. Total colectomy and anterior resection of the rectum with immediate ileo-rectal anastomosis.

The patient made an uninterrupted recovery.

DESCRIPTION OF SPECIMEN.—*Terminal ileum, colon, and part of rectum*.—There was dilatation of the proximal colon as far as the middle of the transverse colon with thinning of its walls and flattening of the mucosa but no evidence of ulceration. The transverse colon and commencement of the descending colon show considerable narrowing of the lumen and thickening of the wall with heaping up of the mucosa. The distal colon has a wider lumen and a considerably fibrosed but thinner wall with completely flat mucosa.

Histology.—Shows in all areas an essentially similar picture of ragged ulceration, œdema of the wall, lymphocytic infiltration and early fibrosis. No evidence of malignancy.

FOLLOW-UP.—The patient made good progress and was seen on Dec. 6, when her general condition was good and she had 5 or 6 bowel actions in 24 hours.

Case 3.—Female, aged 55, married, was seen on May 10, 1954, complaining of diarrhœa.

HISTORY.—At the age of 16 patient began to have abdominal pain, blood in the stools and two bowel actions a day. This continued in attacks until thirteen years ago, with remissions up to three years. Then the diarrhœa became severe with six bowel actions a day and three at night, with blood in the stools. She was admitted to another hospital and a diagnosis of ulcerative colitis was made for which she was given conservative treatment. She was well until one year ago when the diarrhœa and blood in the stools recurred; recently she has had sixteen bowel actions in 24 hours with central abdominal pain before defæcation. She passes a lot of blood in the stools. She states that in bed she desires to defæcate more when lying on the left side than on the right. Anorexia, nausea, and faintness are experienced. Has lost 1 stone in three months.

ON EXAMINATION.—General nutritional state is good. Abdomen—no physical signs present.

Proctoscopy.—Mucopus present. Mucous membrane is granular, œdematous, and friable. At 11 cm. polyps appear and increase up to 15 cm. The lower 8 cm. of the mucous membrane shows less severe changes. Ampulla is distensible.

Rectal Biopsy.—There is considerable mucosal cellular infiltration of round and plasma cell type. Occasional ulcers are seen but no crypt abscesses. Mitotic activity in the crypts is not marked.

Radiological Examination of the Colon after Air Replacement Enema.—There are changes characteristic of a distal procto-colitis affecting the sigmoid and lower part of the descending colon.

Blood-urea 25 mg. per cent. W.B.C. 8000 per c.mm. Hb 81 per cent. Liver function tests: serum-bilirubin—direct 0·2 mg. per cent, indirect 0·1 mg. per cent, total 0·3 mg. per cent; serum alkaline phosphatase 6 units; thymol turbidity 1 unit; thymol flocculation 0 unit per cent; serum colloidal gold 0 unit; zinc sulphate 3 units; ammonium sulphate 1 unit.

It was decided to carry out radical surgical treatment on account of the severity of the patient's symptoms over a long period of time.

AT OPERATION.—July 2. Total colectomy and anterior resection of the rectum with immediate ileorectal anastomosis. The patient made an uninterrupted recovery.

DESCRIPTION OF SPECIMEN.—*Terminal ileum, colon, and part of rectum*. The ileum appears normal. The cæcum and transverse colon are dilated and the wall is somewhat thin. In the cæcum some mucosal pattern is retained but there are areas of submucosal hæmorrhage. The transverse colon is completely smooth. The descending colon and the terminal sigmoid show punched-out ulcers in an otherwise smooth mucosal background. The lumen is grossly narrowed. The mesenteric fat is increased and œdematous and there are deeper ulcers between lumpy mucosa.

HISTOLOGY.—The appendix, terminal ileum, cæcum, and proximal transverse colon are normal. In the hepatic flexure in otherwise normal mucosa are cysts filled with pus but no evidence of any break through. In the descending colon and sigmoid there is irregular ragged ulceration with granulation tissue lining the lumen and some evidence of mucosal degeneration.

FOLLOW-UP.—On Nov. 22, the patient was seen again and found to be well. Her weight is increasing and her appetite is good. She has four or five bowel actions a day and one or two at night; the stools are formed and no blood or mucus is present.

The following case record is included because a total colectomy and anterior resection of the rectum with an ileo-rectal anastomosis were performed but it is pointed out that these were done in stages.

Case 4.—Male, aged 30, single, was admitted to hospital on Oct. 31, 1952, with bleeding and discharge from the rectum; an ileostomy was present.

HISTORY.—Eleven years ago he had amœbic dysentery in the Sudan and this was treated by the usual method including emetine injections. Appendicectomy was performed elsewhere. During the next four years he had at least twenty relapses and courses of injections with emetine were given. His chief symptom was passing pus and blood from the rectum and diarrhœa. After five years a diagnosis of ulcerative colitis was made and the patient was in and out of other hospitals for treatment. Seven years ago he was having chronic diarrhœa and attacks of severer symptoms including abdominal pain and the passage of blood and pus from the rectum. An ileostomy was performed elsewhere followed by a partial colectomy—the pelvic colon was not removed. His condition remained most unsatisfactory; the rectal discharge of blood and pus continued, at times the ileostomy became blocked so that flatus and fluid could not be passed and he experienced abdominal colic, nausea, and vomiting. He then returned to this country in a miserable plight and amongst other symptoms he was passing a half cup-full of blood and pus daily from the rectum.

ON EXAMINATION.—The patient looks toxic, has a flushed face and his general nutritional state is poor. Abdomen—scars of previous operations are present. The ileostomy is satisfactory; there is tenderness in the left iliac fossa. Rectal examination is painful, mucous membrane feels irregular, and pus and blood are present.

Sigmoidoscopy.—8 oz. of bright red blood were evacuated immediately and bleeding from the rectum

continued throughout the examination. The mucous membrane was red and granular. There was no fibrosis or narrowing and no ulcers or polyps were seen at 15 cm. No ova, amœbæ, or cysts were discovered in the rectal discharge.

Hb 80 per cent (11·84 g. per cent); R.B.C. 4,000,000 per c.mm.; C.I. 1·0; W.B.C. 4600 per c.mm. Blood-urea 31 mg. per cent; serum-proteins 6·12 g. per cent; plasma-chlorides 110 m.eq./litre.

Radiological examination after a barium enema showed the pelvic colon but the filling was poor as the enema was returned due to poor sphincter control.

The patient was treated conservatively to determine whether good improvement could be obtained. Temporary improvement did occur but the rectal discharge of blood and pus recurred, and it was decided to remove the pelvic colon.

FIRST OPERATION (Dec. 16, 1952).—Excision of pelvic colon.

DESCRIPTION OF SPECIMEN.—Length of colon measuring 22 cm. There is no normal mucosa present; the wall of the bowel is thickened and there is a marked increase in the pericolonic fat. The mucosal surface is irregular being smooth in some areas and granular in others. Histological examination showed ulceration of the mucosa with almost complete loss of glandular elements. In some cases there is re-epithelialization by flattened cuboidal epithelium. There is lymphoid hyperplasia affecting the submucosa and the lymph-nodes show sinus catarrh. The appearances are those of ulcerative colitis.

After this operation the patient's general condition improved and there was much less bleeding and discharge from the rectum. In June, 1953, sigmoidoscopy showed the appearances of active disease in the upper part of the rectum; these remained the same on sigmoidoscopy on Sept. 29. It was decided to remove the upper part of the rectum and perform an ileorectal anastomosis.

SECOND OPERATION.—Performed on Oct. 13.

DESCRIPTION OF SPECIMEN.—The excised ileostomy shows an area of stenosis of the wall with œdematous thickening, redness and superficial ulceration of the mucosa where it joins the squamous surface. Histological examination shows, in the areas of stenosis, muscle hypertrophy associated with considerable submucous lymphoid proliferation producing true germinal follicles in many areas. There is no giant-cell formation and no evidence of tuberculosis or malignancy. The appearances in the small bowel are those of ulcerative colitis.

The patient made an uninterrupted recovery from the operation and was kept under observation in the out-patient department at regular intervals. On March 22, 1954, his weight was 10 stone 8 lb. and gaining. No abdominal pain. Bowel actions four to six in 24 hours, and he sleeps well without any bowel disturbance at night. The rectum is capacious and the finger can be passed easily through the ileorectal anastomosis; the mucous membrane is still granular and bleeds on touch, but is much better than formerly. A *radiological examination* of the gastro-intestinal tract showed that the œsophagus, stomach, and duodenum were normal. The 2-, 3-, and 4-hour films show some dilatation in the ileum and lower jejunum. The barium began to enter the rectum at 3 hours and practically all of it had reached it by 5 hours. At 24 hours none of it remained and this film shows no evidence of dilatation of the small intestine. None of the films show evidence of inflammatory changes in the small intestine. On Dec. 4, patient wrote saying he leads a happy life and is much more comfortable than when he had an ileostomy; there is now no abdominal colic or rectal bleeding and discharge. His maximum number of bowel actions is ten in 24 hours and his nights are usually undisturbed.

SUMMARY

The indications for surgical treatment in ulcerative colitis are defined. In a selected group of patients total colectomy and anterior resection of the rectum with ileorectal anastomosis gives satisfactory results. The technique of this operation is described. The case records of 4 patients treated by this method are presented.

Acknowledgement.—I wish to thank Dr. George Lumb, Pathologist, Westminster Hospital, for the investigations regarding the pathology.

ANTERIOR SACRAL MENINGOCELE

REPORT OF TWO CASES

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AN anterior sacral meningocele is a cystic presacral swelling caused by protrusion of meninges through a developmental defect in the anterior portion of the sacrum. It is a rare anomaly, occurring most frequently in females. An exhaustive search into the world literature by Eder (1949) revealed only 45 cases; additional cases have been described by Sherman, Caylor, and Long (1950), and Calihan (1952). The total number of recorded cases, including the two reported in this paper, is 54. An interesting historical review of some of the earlier cases is included in a paper by Coller and Jackson (1943).

The dangers of surgical intervention or aspiration must be stressed as many patients are reported (Coller and Jackson, 1943) to have developed meningitis when the true nature of the swelling had not been previously recognized.

CLINICAL FEATURES

Being situated deep in the pelvis and of a cystic nature the lesion may be asymptomatic and its discovery accidental. Symptoms, however, may be caused by pressure of the sac on the anterior sacral rami, the rectum, or bladder. Pressure on the sac by adjacent organs may be transmitted via the spinal canal, and lead to raised intracranial pressure and headache. Calihan (1952) reported a case where headache commenced concomitantly with bowel movement, occurring only when the stools were hard and formed. Headache has also been described as being initiated by coitus. Through its size it may interfere with normal delivery and necessitate Cæsarean section, though Sherman and others (1950) recorded a case in which three vaginal deliveries occurred without unusual difficulty. Its cystic nature serves to distinguish it from solid presacral

lesions, including teratoma, chondroma, chordoma, plasmocytoma, and ependymoma. Presacral dermoid cysts, however, may present with physical signs very similar to those of anterior sacral meningocele, and both lesions have a higher incidence in females. Laird (1954) recorded seven such cysts and noted in all of them the presence of a communicating sinus localized in the posterior midline of the anal canal, within the anal verge, but inferior to the dentate margin. The very characteristic radiological findings, however, will usually confirm the diagnosis of anterior meningocele.

FIG. 343.—*Case* 1. Plain film showing defect in anterior portion of sacrum.

FIG. 344.—*Case* 1. Myelogram demonstrating entry of lipiodol into the sac.

FIG. 345.—*Case* 1. Cystogram. The bladder is seen to be displaced upward and laterally.

FIG. 346.—*Case* 1. Barium enema. The rectum is grossly distended. The sac is seen clearly outlined by lipiodol.

RADIOLOGICAL DIAGNOSIS

The sacral defect is demonstrable on a 'plain' film. One or both sides of the sacrum may be affected, usually in the lower half. The most common anomaly is a unilateral agenesis resulting in a curvilinear defect with deviation of the sacrum and coccyx to the opposite side producing a so-called 'scimitar' sacrum (Coller and Jackson, 1943 ; Brown and Powell, 1945 ; Pool, 1952).

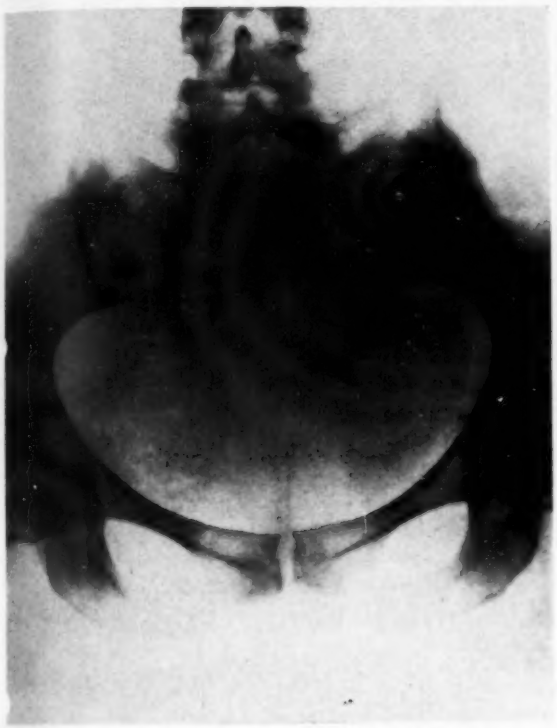

FIG. 347.—*Case* 2. Plain film, showing typical 'scimitar' sacral deformity.

Proof of the existence of the sac may be obtained by myelography, the radio-opaque material gravitating into it from the lumbar subarachnoid space. The communication between the two is often small and funicular, preventing the immediate entry of radio-opaque material into the sac. It is advisable, therefore, to repeat the radiological examination after a week or a fortnight if an immediate outline is not obtained. In the second of the two patients recorded here a fortnight elapsed before adequate contrast definition was obtained. Additional radiological examination, such as by a barium enema or cystogram may be used to demonstrate extrinsic pressure by the sac on the rectum or bladder.

TREATMENT

A high mortality-rate accompanies any radical or palliative procedure. In a collected series of 26 cases in which surgery was performed, meningitis developed in 15 cases, with 11 fatalities (Sherman and others, 1950). In the light of the statistics these authors were of the opinion that the lesion is one which is 'best treated by skilful neglect'. There would appear to be no urgent indication for surgical interference in the absence of pressure symptoms or pregnancy.

The sac itself does not usually secrete spinal fluid and if treatment becomes necessary excision of the sac is not necessary on this account. Simple aspiration of the cyst has in certain recorded cases been followed by lasting cure. This can only be explained by spontaneous closure of the connexion between the sac and the spinal canal subsequent to the aspiration. Aspiration may be performed, as in *Case* 1, between the tip of the coccyx and the anus. All authors agree on the inevitable development of a fatal meningitis if aspiration is performed through the rectum or vagina. Coller and Jackson (1943) advise approaching the tumour through a posterior midline incision, emptying the cyst and ligating its pedicle. This major procedure would seem to be a preferable method of treatment to percutaneous aspiration, as with the pedicle ligated the risk of retrograde infection to the meninges is removed, and refilling of the sac is prevented.

FIG. 348.—*Case* 2. Barium enema, demonstrating lateral displacement of rectum.

CASE REPORTS

Case 1.—Miss M., aged 22, was admitted to the Royal Infirmary, Sheffield, on July 10, 1945, suffering from acute retention of urine. She gave a history of occasional difficulty in micturition for the preceding 12 months, having on one occasion been unable to pass urine for eight hours.

ON EXAMINATION.—The bladder was enormously distended and 43 oz. of urine were removed by catheter. Rectal examination revealed a large cystic presacral swelling whose true nature was not at the time appreciated. Inability to micturate continued.

AT OPERATION.—An exploratory laparotomy was performed on July 12. A large cystic swelling was found to occupy most of the pelvis, displacing the bladder

upward into the abdomen and the swelling was then recognized to be an anterior meningocele. The sac was opened, a large quantity of spinal fluid evacuated, and the operative opening in the sac sutured.

The patient made a good recovery from operation and normal micturition was established. One month later radiological investigations proved that the condition was indeed an anterior sacral meningocele. A characteristic bony defect was demonstrated (*Fig.* 343) and a myelogram showed that a large amount of lipiodol entered the sac (*Fig.* 344). A cystogram (*Fig.* 345) indicated that the cyst had refilled and that considerable upward and lateral displacement of the bladder was present. In the absence of symptoms no further treatment was thought advisable and the patient was discharged.

In February, 1946, the patient was re-admitted complaining of increasing constipation. There was no difficulty in micturition. Examination revealed abdominal distension and the continued presence of a large presacral cystic swelling. A barium enema demonstrated gross distension and displacement of the rectum (*Fig.* 346). Lipiodol was still demonstrable in the sac and clearly outlined its relation to the rectum. As the constipation remained unrelieved a further abdominal exploration was undertaken on March 6. The large bowel was found to be enormously distended with fæces and gas. No obstructive lesion in the sigmoid or upper rectum could be found and the obstruction was thought to be due to extrinsic pressure from the cyst which continued to fill the pelvis. The gross bowel distension prevented a good exposure of the cyst wall. The abdomen was, therefore, closed and the sac aspirated by means of a needle inserted into it from below the coccyx, over a pint of spinal fluid being removed. The patient made an uneventful recovery and normal bowel function returned. In 1948 the patient married and in 1950 became pregnant. The size of the cyst was regarded as a bar to normal delivery and a Cæsarean section was successfully performed. To date the patient remains well and symptom free in spite of the continued presence of the anterior meningocele.

Case 2.—Mrs. S., aged 22, attended a contraception clinic and was found to have a large cystic presacral swelling. She was free of symptoms. A radiograph of the pelvis showed a characteristic 'scimitar' sacrum with the characteristic deficiency (*Fig.* 347). A mano metric rise of 40 mm. in the C.S.F. pressure was demon strated when pressure was exerted on the tumour pe rectum with a lumbar puncture needle in situ. A myelogram (Myelodil 2 c.c.) failed to outline the sa though a little was seen at a radiological examination tw weeks later anterior to the sacrum. A barium enem showed the rectum to be displaced to the right wit evidence of extrinsic pressure (*Fig.* 348). The clinic and radiological findings were unequivocally those of a anterior sacral meningocele. In the absence of symptom no radical surgery was advised. It is anticipated th Cæsarean section will be necessary if pregnancy occurs.

SUMMARY

1. Two cases of anterior sacral meningocele are described, the total number of recorded cases now being 54.

2. The physical signs, diagnosis, and radio logical features of the condition are discussed.

3. There is no immediate indication for surgica interference in the absence of pressure symptoms.

4. Normal childbirth is usually impossible Cæsarean section being necessary.

I wish to thank Professor R. St. Leger Brockman for permission to publish *Case* 1, Professor C. Scot Russell for referring *Case* 2, and Professor R. P Jepson, under whose care it was investigated.

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LYMPHATIC CYSTS OF THE MESENTERY

A REVIEW OF THE LITERATURE AND A REPORT OF TWO CASES

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IN 1507 Benviene, the Florentine anatomist, found at autopsy the first mesenteric cyst and described it as an anatomical marvel. Since then about 600 mesenteric cysts have been described of which, according to Slocom (1938), less than half were true lymphatic cysts and of these only 200 were causing symptoms.

That the condition is rare there can be no doubt. Bearhs and Judd (1947) found only 7 cases among more than a million patients at the Mayo Clinic and Roller (1935) examining the records of the Massachusetts General Hospital during the first twenty-six years of this century found only 6 cases, and only one case in 188,000 admissions to the Los Angeles General Hospital. Indeed, Flynn (1930) described mesenteric cysts as the rarest of all abdominal tumours.

Two typical examples of this unusual condition have been encountered recently and they are thought to be of sufficient interest to merit description.

CASE REPORTS

Case 1.—No. 225252. A 29-year-old man attended the Medical Out-patient Department of the Leicester Royal Infirmary in March, 1954, complaining of colicky abdominal pain for eight weeks. The pain occurred fifteen minutes after meals and persisted for some hours. Physical examination revealed no abnormality. A barium meal with follow-through series only showed an upward displacement of the distal ileum suggestive of a space-occupying lesion in the lower abdomen.

Subsequently the patient failed to attend out-patient and was next seen in December, 1954, when he was admitted to hospital because of an abdominal swelling

which was said to have been present for one month (*Fig.* 349). In the twenty-four hours preceding admission the patient had vomited several times and had had central abdominal pain. He was afebrile and examination of the abdomen revealed a firm round smooth swelling extending from pubis to umbilicus. This tumour was mobile and showed a tendency to disappear under the left costal margin or into the pelvis from which positions it could only be dislodged with difficulty. A radiograph

FIG. 349.—The suprapubic abdominal swelling caused by the lymphatic cyst (*Case* 1).

of the abdomen showed no abnormality but an intravenous pyelogram showed 'a filling defect in the bladder shadow due to extrinsic pressure'. There was normal filling and function of both kidneys. A provisional diagnosis of a mesenteric cyst was made.

AT LAPAROTOMY.—A cystic swelling 8 in. (20 cm.) in diameter was found in the jejunal mesentery about 12 in. (30 cm.) from the duodeno-jejunal junction (*Fig.* 350). The small bowel was stretched over the tumour but not obviously obstructed by it. The cyst bulged primarily on the upper surface of the mesentery and it was removed from this surface. Many jejunal vessels surrounded the tumour but it was possible to draw these aside while the cyst was excised. The blood-supply to the cyst was contained in one small pedicle entering near the root of the mesentery and not connected with the vessels of the gut.

The patient made an uneventful recovery and was sent convalescent to a branch hospital on his eighth post-operative day.

HISTOLOGY REPORT.—(Dr. E. Milford Ward.) This unilocular cyst weighs 1020 g. and is 18 cm. in diameter. It is filled with a thick creamy fluid and the wall varies in thickness between 1 and 5 mm.

The wall consists of fibroblasts and in it are large dilated lymphatic channels. There is no lining membrane but in the lumen are many fat laden macrophages. There is some round cell infiltration of the wall with the presence of lymphorrhages (*Fig.* 351).

This cyst appears to be lymphatic in origin.

Case 2.—No. 142095. An eight-year-old boy was admitted to Leicester Royal Infirmary in February, 1955, because he had had for some years recurring attacks of central abdominal colic and associated tenderness in the right iliac fossa. On examination he was tender in the region of McBurney's point, where a mass was felt which moved easily up and down the right side of the abdomen. It was thought to be the right kidney.

AT LAPAROTOMY.—The mobile abdominal swelling was found to be a multilocular cyst in the ileal mesentery about 12 in. (30 cm.) from the ileo-cæcal valve (*Fig.* 352). The cyst was between 4 and 5 in. (10-12·5 cm.) in diameter and had thin transparent walls quite distinct from those of the bowel. The loculi bulged from both surfaces of the mesentery and almost enveloped the ileum which was narrowed by the pressure of the cyst. Because some loculi of the cyst lay amongst the blood-vessels supplying the ileum, a safe and adequate removal of the cyst could only be carried out by resecting adjacent ileum as well, the continuity of the bowel being restored by a side-to-side anastomosis. No other cysts were found in

FIG. 350.—The lymphatic cyst at operation (*Case* 1).

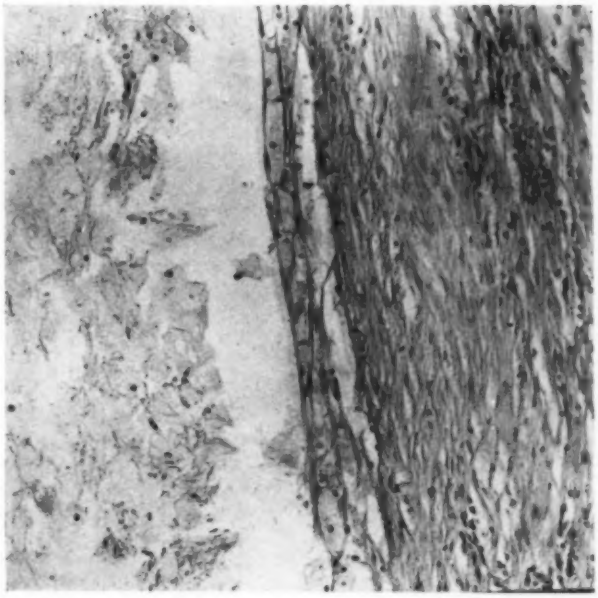

FIG. 351.—Photomicrograph of the cyst wall (*Case* 1). (L.P. × 130.)

the mesentery although there was a marked mesenteric lymphadenopathy. The child made an uneventful recovery and was sent home on the fourteenth post-operative day.

PATHOLOGY REPORT.—(Dr. E. Milford Ward.) The specimen consists of 6 in. (16 cm.) of small intestine in the mesentery of which is a multilocular cyst. The main loculus is $2\frac{1}{2} \times 2 \times 1\frac{1}{2}$ in. (6·25 × 5 × 3·75 cm.) and there are two other major loculi measuring $1\frac{1}{2} \times 1 \times \frac{3}{4}$ in. (3·75 × 2·5 × 1·8 cm.) and 2 × 1 × $\frac{1}{2}$ in. (5 × 2·5 × 1·25 cm.). The bowel is compressed between the two largest loculi. Dilated blood-vessels course over its surface. The cyst contains a milky fluid. The inner wall is quite smooth. In one small locule the material is

cheeselike in consistency and appearance. There is no communication with the bowel. Section of the wall shows smooth muscle and fibrous tissue. An occasional flattened endothelial cell is present on the inner surface of

FIG. 352.—The lymphatic cyst at operation (*Case* 2).

the wall (*Fig.* 353). The cyst appears to be lymphatic in origin. Analysis of the fluid in the cyst showed it to contain cholesterol, fat, a large amount of fibrin, urea 21 mg. per cent, sodium 139 Meq/litre, potassium 3·6 Meq/litre, and chloride 97 Meq/litre.

CLASSIFICATION

In 1897 Moynihan described and classified cysts of the mesentery, and he based his classification on the physical characteristics of the contents. Subsequently Dowd (1900) wrote his classic paper in which cysts of the mesentery were described as embryonic, hydatid, and malignant, a sounder classification using a pathological basis. In the next three decades various descriptive classifications were made which were not very satisfactory because no critical attempt was made to separate lymphatic from enterogenous cysts. Roller was among the first to make this distinction between chylous cysts and 'embryonic inclusion tumours' including in the latter group dermoid duplications and cystic remnants of the Wolffian body and duct. This type of classification was elaborated by Petersen (1940) who described mesenteric cysts as either embryonic which included Roller's types or pseudocysts in which group were infective and hydatid cysts and cystic malignant disease.

Ewing's classification (1942) is the most recent and simple. He considered all true cysts of the mesentery fell into four groups :—

1. Lymphatic or chylous.
2. Enterogenous or duplications of the gut.
3. Urogenital.
4. Dermoid or teratomatous.

Dermoid cysts, the origin of which is in doubt, are much more rare than lymphatic cysts but they look and behave like dermoid cysts elsewhere in the body. Urogenital cysts are thought to arise from Wolffian remnants and are essentially retroperitoneal but are included in the classification because it is not impossible for them to be projected forward into the mesentery. So any true cyst of the mesentery is almost always either lymphatic in origin or a duplication of the gut.

AETIOLOGY

The way in which a lymphatic cyst forms in the mesentery is not known but the theory proposed by Gross (1953) is currently accepted by many. He believes that lymph fluid accumulates in congenitally misplaced lymphatic tissue which has no efferent communication with the rest of the lymphatic system.

Ewing considered these cysts to be lymphangiomata, that is benign tumours of embryonic origin, and this alternative theory of formation is accepted by Thompson and Chambers (1946) who referred to lymphatic mesenteric cysts as chylangiomata. This would not seem to be a good descriptive term because only in fifty per cent of cases does the contained fluid resemble chyle. On the other hand, Willis (1953) does not believe that lymphatic cysts are true tumours, there being no evidence of a proliferative invasive process and he regards them as vascular malformations comparable to hæmangioma. Among other theories of causation that proposed by Lee (1942) is of interest. On the basis of animal experiments he has suggested that a lymphatic cyst would form if a lymphatic channel was ruptured. In the past others have held the view that these cysts arise because of inflammatory obliteration of efferent

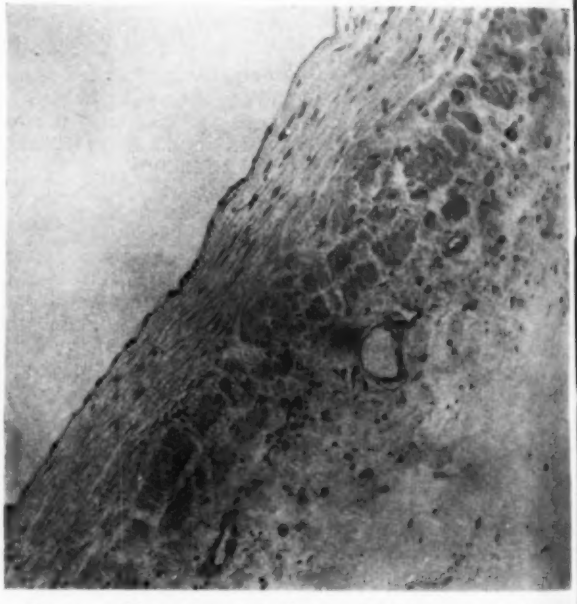

FIG. 353.—Photomicrograph of cyst wall showing some bundles of smooth muscle (*Case* 2). (L.P. × 130.)

lymphatics but this concept is not now accepted because the lymphatic network is so vast that it is thought other channels would take over.

INCIDENCE

Lymphatic cysts, either uni- or multi-locular, are usually solitary but Gross does mention an extremely rare variant of the condition in which myriads of cysts are found in the various mesenteries of the abdomen.

Warfield (1932) reviewed 129 collected cases and found 61 in the mesentery of the small bowel of which 31 were related to the ileum, 50 in the large bowel mesentery, and the site of the remainder was

not mentioned in the literature he reviewed. He found them to occur rather more frequently in females than males. Lymphatic cysts of the mesentery can be found at any age and Miller (1954) has reported a case in a twenty-day-old infant. While in Warfield's review the greatest age incidence was in the fourth decade with age limits extending from one to seventy years, Higgins and Lloyd (1924) found the greatest incidence to be in the second decade.

PATHOLOGY

Lymphatic cysts and enterogenous cysts occur in similar anatomical sites and exhibit the same physical signs but they can usually be distinguished on naked eye appearance. Lymphatic cysts are always separate from neighbouring bowel while the muscle in the wall of an enterogenous cyst is apparently continuous with that in the adjacent gut and separation between the two is impossible. Lymphatic cysts have a blood-supply independent of that to the adjacent bowel and often can be removed simply. Enterogenous cysts, however, have a common blood-supply with the bowel to which they are related and consequently their removal always entails a resection of gut in addition.

On histological examination the walls of lymphatic cysts are composed primarily of connective tissue with a flat and sparse endothelial lining ; enterogenous cysts have thicker walls of smooth muscle and an inner lining of mucous membrane. Thompson and Chambers state that occasional bundles of smooth muscle may be found in the walls of a lymphatic cyst but never in the continuous layer that is found in an enterogenous cyst. Ewing goes further than this and states that the walls and septa within a lymphatic mesenteric cyst may contain sufficient smooth muscle to throw doubt on this being a distinguishing feature from enterogenous cysts. The most important distinguishing histological feature between these two types of cysts of the mesentery is the type of lining membrane.

CONTENT

Lymphatic cysts contain a fluid of varying composition. It can be of two main types, one serous, clear, and watery, the other chylous, opaque, and whitish-yellow, varying in consistency from that of milk to thick cream. In Gross's series of twelve cases, seven were serous and five chylous, and on analysis the serous cysts contained a fluid closely resembling plasma and the chylous ones a fluid containing much less protein than plasma and a high fat content of 7 per cent. Gross believes that the more proximal a cyst is in the small bowel, the more likely is it to be chylous because of the higher fat content of the lymph draining from the jejunum. All the cysts in his series related to the distal ileum and colon were serous.

The second case reported in this paper does not conform to Gross's generalization because it was chylous and situated in the distal ileum. Thompson and Chambers reviewing three papers found there was wide disparity in the analyses published therein, the fat content ranging between 4·5 per cent and 35·8 per cent and the protein between 1·97 per cent and 3·57 per cent.

CLINICAL COMMENT

Lymphatic cysts manifest themselves by a slow painless enlargement of the abdomen, by recurring attacks of abdominal pain and vomiting, or more rarely by an acute obstructive episode such as a volvulus. Moynihan taught that a rapid loss of weight was significant but this is not now accepted. Pain is a much more constant feature. The cause would seem to vary, in most cases the pain is related to the degree and type of obstruction that the cyst is causing, but Handelsman and Ravitch (1954) suggest that where the tumour is large, pain is produced by traction on the root of the mesentery. Examination of the specimens removed from the two cases described in this report suggests that the pain of which both patients had complained resulted from the recurring temporary impaction of a food bolus in a segment of bowel narrowed by the cyst.

Lymphatic cysts are more tense in the later age groups and Bogle (1954) believes these are usually serous, while chylous cysts which occur more often in children may be sufficiently large and flabby to show shifting dullness. Handelsman and Ravitch in their report of 4 cases in children found that in 3 patients the cyst was not palpable pre-operatively and that these cysts were so flabby that after removal they ran in an amœboid fashion to adopt a ' flat discoid shape '. If the tumour is palpable, mobility can usually be demonstrated and is greatest at right angles to the line of attachment to the mesentery.

Among the complications that have been described in lymphatic cysts, Warfield lists obstruction due to narrowing, kinking volvulus adhesions and intussusception, hæmorrhage, torsion, rupture, and impaction. Calcification has been reported once by Vaughn, Lees, and Henry (1948).

Lymphatic cysts enter into the differential diagnosis of all mobile intra-abdominal tumours. There is, however, no pre-operative investigation which will confirm the diagnosis of a cystic tumour in the mesentery but an intravenous pyelogram should be performed to exclude a renal cause for the abdominal swelling and a barium meal with a follow-through series may help by showing a displacement of the intestinal pattern.

TREATMENT

The procedure of choice is a simple removal of the cyst ; this is reported to have a mortality of 9 per cent. When a simple removal of the cyst is likely to damage the mesenteric vessels, the alternative procedure is to remove the cyst and resect the adjacent bowel. In papers written before World War II, this more radical procedure carried a mortality of 25–30 per cent. There is no doubt that this figure does not obtain to-day and that the prognosis is very much better. Of all the cases reported since 1945, death has occurred in only two. Both of these were in Gross's series where the lymphatic cyst had caused a volvulus and an extensive infarction of the bowel. All writers are agreed that this type of case carries the highest mortality.

Other methods of treatment include aspiration and marsupialization. The latter has been practised in the past and is said to have a low mortality but invariably a persistent sinus is produced requiring a

further and usually difficult operation. Aspiration may be employed at laparotomy to diminish the size of a cyst to enable its removal to be made more easily.

It is said that very rarely a lymphatic cyst cannot be safely removed because it involves a vital structure. In this type of case it would seem reasonable to anastomose the largest loculus to adjacent bowel in the same way that choledochal and pancreatic cysts are sometimes treated.

PROGNOSIS

The prognosis is excellent and the mortality that of the operation. Only if the very rare condition of multiple mesenteric cysts exists is the prognosis poor. This is because the cysts are often so numerous and widespread that their surgical eradication is impossible and sooner or later hopeless intestinal obstruction will develop.

SUMMARY

Two cases of lymphatic cyst of the mesentery of the small intestine are reported.

The mode of formation of this rare condition is not known but is discussed.

Lymphatic cysts must be distinguished from duplications of the bowel.

The treatment is either simple excision of the cyst or excision of the cyst and the adjacent loop of bowel.

The prognosis is probably better than previously published figures suggest.

These cases were admitted under the care of Mr. E. R. Frizelle and Mr. Donald McGavin, and I would like to thank them and Sir Ernest Finch for their help in the preparation of this paper.

I am also indebted to Mr. R. W. T. Gaze, F.I.M.L.T., for the photographs.

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CHOLANGIOGRAPHY IN HEPATIC HYDATID DISEASE

By W. R. PROBERT

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OCCASIONALLY the biliary tract is unexpectedly outlined during radiological examination of other organs. Franklin (1954) reported this happening during examination by barium enema of a patient who had a persistent cholecystocolic fistula associated with a stone impacted at the ampulla of Vater.

In the case reported here the biliary tract was outlined by a sinogram done to determine the size of a residual cavity in the hepatic region after an operation for hydatid disease.

CASE REPORT

A woman aged 58 years had been ill in February, 1949, with jaundice and left-sided pneumonia. In September, 1949, she had been treated at another hospital for acute cholecystitis. Three days after returning home she developed pain beneath the left costal margin. Signs of left basal pneumonia were found, and she received treatment, including penicillin and sulphatriad, at home. Remittent fever continuing, and marked dullness to percussion persisting after ten days, she was admitted to hospital with a suspected empyema on Oct. 31. Though latterly living in the Home Counties, she had spent her early years on a Glamorganshire sheep farm, living in close association with dogs.

ON ADMISSION.—She was found to be pyrexial, dyspnœic, and mildly jaundiced. The abdomen was a little distended. A swelling palpable three finger-breadths below the right costal margin had a smooth edge and was moderately tender. The chest was dull to percussion at the left base, vocal resonance was diminished, and breath-sounds were faint. Crepitations were heard over the base of the right lung. Hæmoglobin was 76 per cent, leucocyte count 8000 (polymorphs 70 per cent, lymphocytes 26 per cent, monocytes 4 per cent). E.S.R. (Wintrobe) was 55 mm./hr. (corrected 30 mm./hr.). P.A. film of chest (*Fig.* 354) showed some fluid at the left base. The left hemidiaphragm seemed high, but unfortunately left lateral and penetrating films were not taken; nor was fluoroscopy done.

Diagnostic aspiration of the chest through the eighth intercostal space in the left mid-axillary line produced thick yellow pus. (Film examination: Polymorphs 35 per cent; monocytes 60 per cent; macrophages 5 per cent. Culture: penicillin-sensitive non-hæmolytic streptococci.)

The pyrexia settled by Nov. 2, 1949, but recurred two days later. The clinical history, the presence of a tender abdominal swelling, and the suspicion that the pus was really below the diaphragm led to the decision to explore the abdomen.

AT OPERATION.—Laparotomy through a right upper paramedian incision was performed by Mr. R. Strang on Nov. 8. The gall-bladder was chronically thickened and subacutely inflamed. The common bile-duct was of normal size, and was normal on palpation, but it was not opened for exploration. In the left lobe of the liver there was a large abscess. It bulged between the layers of the lesser omentum, and communicated with a left suprahepatic subphrenic abscess, but had no direct relationship to the gall-bladder itself.

The gall-bladder was removed. It was full of mucopus and a small pigment stone was impacted at its neck. The abscess of the liver and left suprahepatic space was evacuated and drained. It was then recognized to be an infected hydatid cyst with numerous daughter cysts (*Echinococcus granulosus* microscopically confirmed). At the end of the operation the anæsthetist aspirated many daughter cysts from the trachea and bronchi. At intervals for two days after operation the patient coughed up daughter cysts. The temperature gradually settled and had returned to normal by the third week after operation.

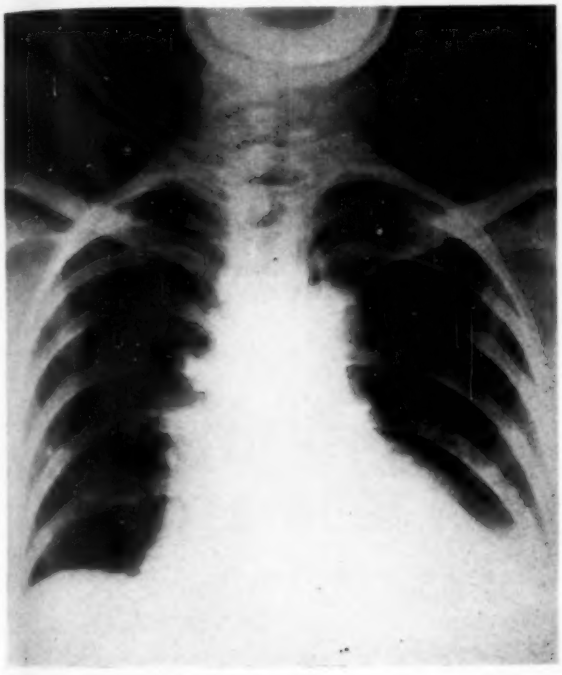

FIG. 354.—Radiograph of chest, showing left pleural effusion.

FIG. 355.—Sinogram six weeks after operation, defining bile-ducts and duodenum.

Systemic penicillin was given from operation till Nov. 15, and again from Nov. 18 to Nov. 22. The drainage-tube was gently irrigated with 1 per cent formalin solution daily from Nov. 9. There was no external drainage of bile at any stage.

X-ray examination after lipiodol had been introduced into the drainage-tube on Dec. 22 to determine the size of the residual intra-abdominal cavity resulted in the picture shown in *Fig.* 355. The oil, after filling a small cavity, had entered a bile-duct in the left lobe of the liver. It had outlined the left hepatic duct, the right hepatic duct to a lesser extent, the cystic duct stump, the common bile-duct, and the duodenum.

After this examination, the drainage-tube was removed. A small sinus was still present when the patient went home on Jan. 13, 1950, but had healed when she was examined on Feb. 21. She then appeared very well. The chest radiograph still showed a little fluid at the left base.

The patient reported in a letter dated July, 1953, that she was in good health, that a gain in weight had been maintained, and that she had no chest symptoms.

COMMENT

It seems most likely that in this case an infected hydatid cyst in the left lobe of the liver had been followed by a subphrenic abscess and a bronchial fistula. Such a state of affairs is described by Barrett and Thomas (1952), and is clearly illustrated in their comprehensive paper on pulmonary hydatid disease.

Toole, Propatoridis, and Pangalos (1953) reported a series of cases in which intrapulmonary rupture of hydatid cysts of the liver had occurred. X-ray examination, following the injection of lipiodol into sinuses, demonstrated in one of their cases a large hepatic cavity, and in another a communication between a hepatic cavity and the bronchi of the lower lobe of the right lung. In no case were the bile-ducts defined, though the authors discussed biliary fistulæ at length.

Dillwyn Thomas (1954) has described the case of a desperately ill patient in whom, at thoracotomy, a communication was demonstrated between the right lobe of the liver and an enormous right-sided empyema cavity, numerous hydatid cysts being evacuated from the pleural cavity and from the right lobe of the liver. After operation, bile drained from the wound for several weeks. It is probable that there was a sizeable defect in an intrahepatic bile-duct; and it is possible that sinography would have resulted in a picture similar to that obtained in the present case.

I thank Mr. Robert Strang, who treated this patient, for his help, and Mr. Dillwyn Thomas for the details of his own case, and for his advice.

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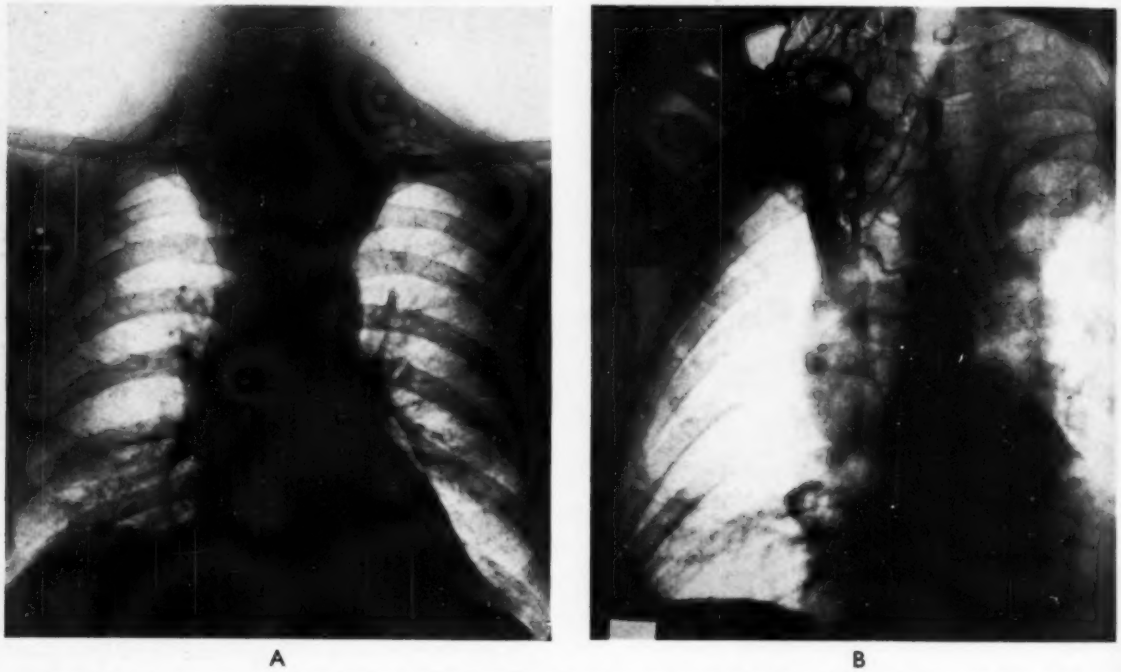
INTRATHORACIC GOITRE

By E. HOFFMAN, Newcastle upon Tyne

Intrathoracic goitre is not a common condition. Wakeley and Mulvany (1940) described 20 cases in a series of 1265 thyroidectomies. In 17 the major portion was situated below the plane of the thoracic inlet and in 3 the whole swelling lay within the thorax. The incidence of intrathoracic goitre among thyroidectomies has been reported as between 0·2 and 3 per cent.

Thirty-two patients with intrathoracic goitre were operated on at the Chest Surgery Centre at Shotley Bridge Hospital in the years from 1942 to 1954. A goitre was accepted as intrathoracic when it was lying entirely within the thorax or when its greatest diameter was below the thoracic inlet. In all these cases the goitre extended to or below the aortic arch.



A B

Fig. 356.—A, Anteroposterior radiograph of an intrathoracic goitre of a man aged 57 with clinical signs of superior vena caval obstruction. B, Venogram of same patient shows compression of the superior vena cava and presence of a well-established collateral circulation.

The ages of these patients ranged from 28 to 73 years, with an average of 58 years. There were 17 male and 15 female patients. Four of the goitres were malignant.

SYMPTOMATOLOGY

The symptoms could be divided into those due to superior mediastinal pressure and those due to thyrotoxicosis. In a few patients the intrathoracic goitre was found at routine examination and had been asymptomatic.

The great majority of patients had symptoms due to superior mediastinal obstruction. It probably takes years for an intrathoracic goitre to become large enough to give rise to pressure symptoms, but once symptoms develop they become intolerable within a few months.

Symptoms are the result of pressure on the trachea, œsophagus, vessels, and nerves.

The trachea is the most rigid and least displaceable structure in the superior mediastinum and symptoms from compression of it are the earliest to appear. Dyspnœa first on exertion and later continuous was the commonest disability. It was present in 18 patients; in 7 of these it occurred only on exertion. Dyspnœa on movement of the head to the opposite side of the tumour was not observed, although this symptom has been described as being typical of this condition.

Respiratory complications of an intrathoracic goitre are frequent and due to tracheal compression. Narrowing of the trachea is also aggravated by venous congestion as the outflow from the trachea is into the inferior thyroid veins. Five of our patients gave a history of pneumonia four weeks to five months prior to admission. In these cases symptoms directly due to the intrathoracic goitre appeared only after this illness. Four of these patients had on admission radiographic evidence of segmental or lobar atelectasis. A persistent dry or productive cough was present in a large proportion of our patients.

Pressure on the large venous trunks interferes with the venous return from the head and neck. Thirteen patients had symptoms due to venous obstruction; 4 had headaches and dizziness, the

remaining 9 described symptoms which included a sensation of pressure or tightness in the neck and various degrees of distress due to choking.

Hoarseness was present in 6 patients; only 1 of these had a malignant goitre. Paralysis of the vocal cord was present in 1 patient, who had had a partial thyroidectomy many years ago.

Eight patients complained of dysphagia. In 4 of these barium swallow showed the œsophagus displaced by the goitre. Keynes (1950) believes that dysphagia is very unusual with an innocent tumour. Seven of our patients, however, had benign goitres.

Thyrotoxicosis is not common in intrathoracic goitre. Lahey (1939), with his vast experience, has never seen a true exophthalmic goitre become intrathoracic. Lahey's (1939) view that an intrathoracic goitre develops from a single nodule or one of several nodules of a nodular goitre is generally accepted. Toxic symptoms, therefore, when present, will be of a milder variety. Five of our patients had thyrotoxic symptoms; in 3 they were mild with loss of weight, sweating, and occasional diarrhœa, and in 2 symptoms were moderately severe with tremor, palpitations, loss of weight, and emotional instability. The mean age of patients with toxic symptoms was 42 years as compared with 58 years in the whole series. Myxœdema was encountered in 1 female patient who had been dyspnœic for fifteen years and had obvious signs of myxœdema for nine months. At operation she was found to have an inoperable carcinoma of the thyroid gland.

Five patients had no symptoms related to the intrathoracic goitre; in 2 the condition was discovered at mass radiography and in 1 was found at a routine X-ray following a pneumonia. In the other 2 the goitre was discovered during investigations for a duodenal ulcer and hiatus hernia.

CLINICAL FINDINGS

In 17 patients a goitre was present in the neck; in 5 of these the goitre was bilateral; in 6 the gland was obviously nodular.

Fifteen patients had a completely intrathoracic goitre with no thyroid enlargement in the neck, but in 7 of these a mass could be felt on swallowing arising from the superior mediastinum.

Dilatation of the veins of the chest wall and neck was evident in 9 patients; in 6 others only the neck veins were distended and were often pulsating.

The radiological appearances showed the typical broad superior mediastinal pyramidal density with the base uppermost and the apex below. In 9 cases the opacity extended below the level of the aortic arch. The trachea was shown to be displaced in all patients but one. The displacement was moderate or severe. Tracheal compression was frequently present. Goitres arising from the left lobe of the thyroid caused more marked displacement and compression than those arising from the right. Of 10 cases with the highest degree of tracheal compression, 8 were due to left-sided goitres. All goitres except one moved on swallowing. There was no evidence of fixation in the 4 malignant cases.

Barium-swallow examination was carried out routinely. Displacement of the œsophagus was found in 14 patients. In 12 of these the displacement was to the right and was caused by left-sided goitres.

Calcification was seen in 3 goitres.

Unilateral paralysis of the diaphragm was found in 4 patients, all of whom had benign goitres. Three of these were on the left and 1 on the right side. This paralysis was presumably due to stretching of the phrenic nerve by the intrathoracic goitre, as in a few cases the taut phrenic nerve was seen at operation on the surface of the intrathoracic mass.

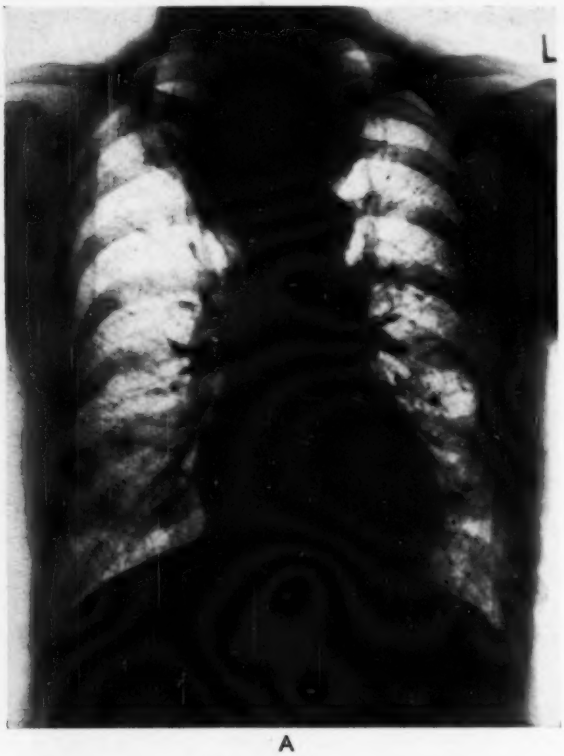
FIG. 357.—Anteroposterior film of an opacity low down in the mediastinum which proved to be an intrathoracic goitre. This patient had two thyroid adenomas removed for thyrotoxicosis twelve years previously. The intrathoracic mass was removed through a thoracotomy incision; a fibrous pedicle was found which extended towards the thyroid gland.

The B.M.R. was markedly raised in 2 cases with thyrotoxicosis to +96° and +78° respectively. The patients, however, were only moderately toxic as they had had a course of methylthiouracil prior to admission.

Of our 32 cases the intrathoracic goitre originated in 19 from the left and in 13 from the right lobe of the thyroid. Two of the cases were bilateral, with a small retrosternal extension from the other side. Intrathoracic goitre is usually described as an anterior mediastinal growth. Only 12 of our cases, however, were entirely in the anterior mediastinum; 16 extended from the anterior into the posterior mediastinum, accepting the division as being a sagittal plane passing in front of the bifurcation of the trachea; 4 goitres were entirely in the posterior mediastinum. Tomkinson (1951) found only 15 cases of posterior mediastinal goitre in the literature, to which he added 2 cases of his own. The direction of growth of an intrathoracic goitre will depend largely on the site of the nodule it started from and on the resistance of structures it encounters. The intrathoracic extension will eventually come to lie in

front of the large vessels, between the venous and arterial trunks or posterior to both. It may track along the trachea and œsophagus and assume a retrotracheal or retro-œsophageal position. The strict anatomical division of intrathoracic goitre into those of the anterior and posterior mediastinum is largely artificial.

Of our 16 goitres which extended from the anterior into the posterior mediastinum, 12 were on the left side. It has already been mentioned that



A

B

C

FIG. 358.—A, Anteroposterior radiograph of an intrathoracic goitre in a female patient of 66 who had had a symptomless goitre for twenty years. For the last two months she had become progressively dyspnœic and developed marked dysphagia. B, Barium swallow showing both the trachea and œsophagus displaced to the right. C, Lateral film of a barium swallow in the same patient showing a posterior mediastinal goitre pushing the trachea forward and the œsophagus backward.

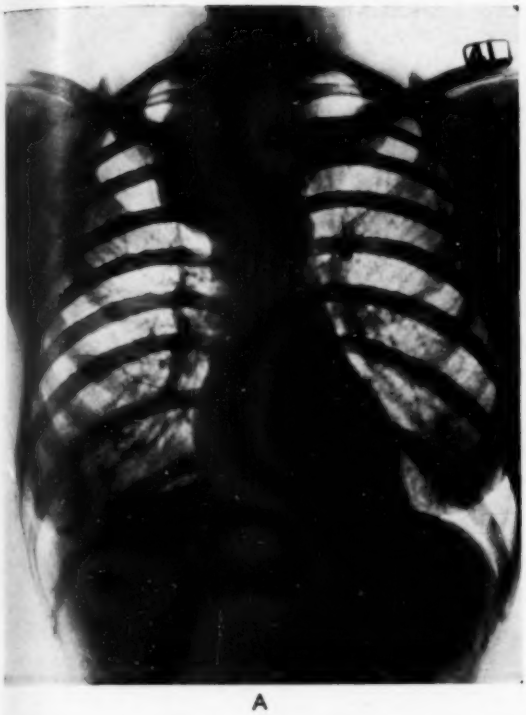
early tracheal compression and œsophageal displacement are more common on the left side. This may well be explained by the difference of anatomy on either side. The arrangement of vessels on the left offers a firmer resistance, favouring extension into the posterior mediastinum and leading to early compression of the trachea and œsophagus.

MALIGNANCY

Only a few cases of malignant intrathoracic goitre have been recorded.

The symptoms of our 4 patients who proved to have a carcinoma of the thyroid did not differ from those of a benign goitre. In 2 patients there was only a short history of dyspnœa of three and five months' duration respectively, 1 had three previous operations for thyrotoxicosis, and 1 had the typical symptoms of myxœdema.

On examination there were clinical signs suggestive of malignancy. In 1 the goitre was fixed to the muscles of the neck and in 2 the trachea felt rigid at bronchoscopy and bled very easily. Another patient was seen a year before, refusing operation at



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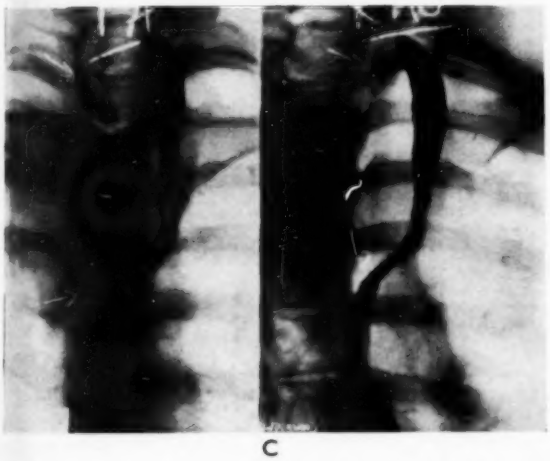

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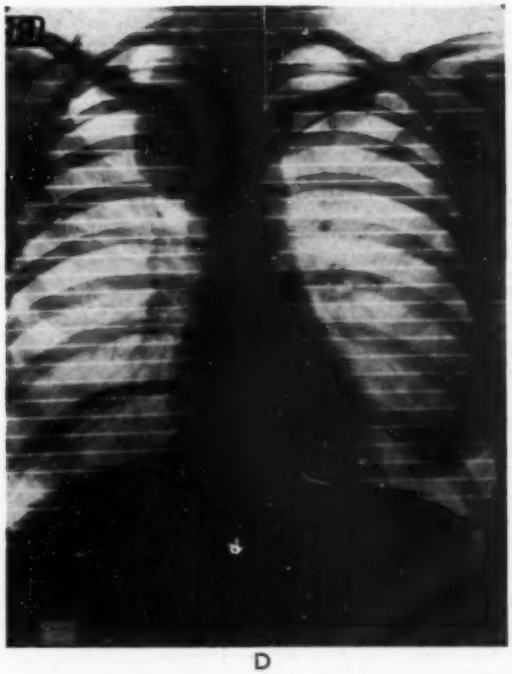


D

FIG. 359.—A, Anteroposterior radiograph of an intrathoracic goitre in a female aged 28, discovered at a M.M.R. examination. She had had an attack of pneumonia six weeks earlier. B, Lateral film of the same patient, showing a goitre located mainly in the posterior mediastinum. C, Film showing the œsophagus displaced in the postero-anterior and right anterior oblique views. D, Kymogram of same patient, demonstrating absence of pulsation of the intrathoracic mass.

that time. When seen again there was marked enlargement of the goitre and great deterioration in the patient's condition.

In 3 patients exploration only was carried out and in 1 the intrathoracic mass was removed.

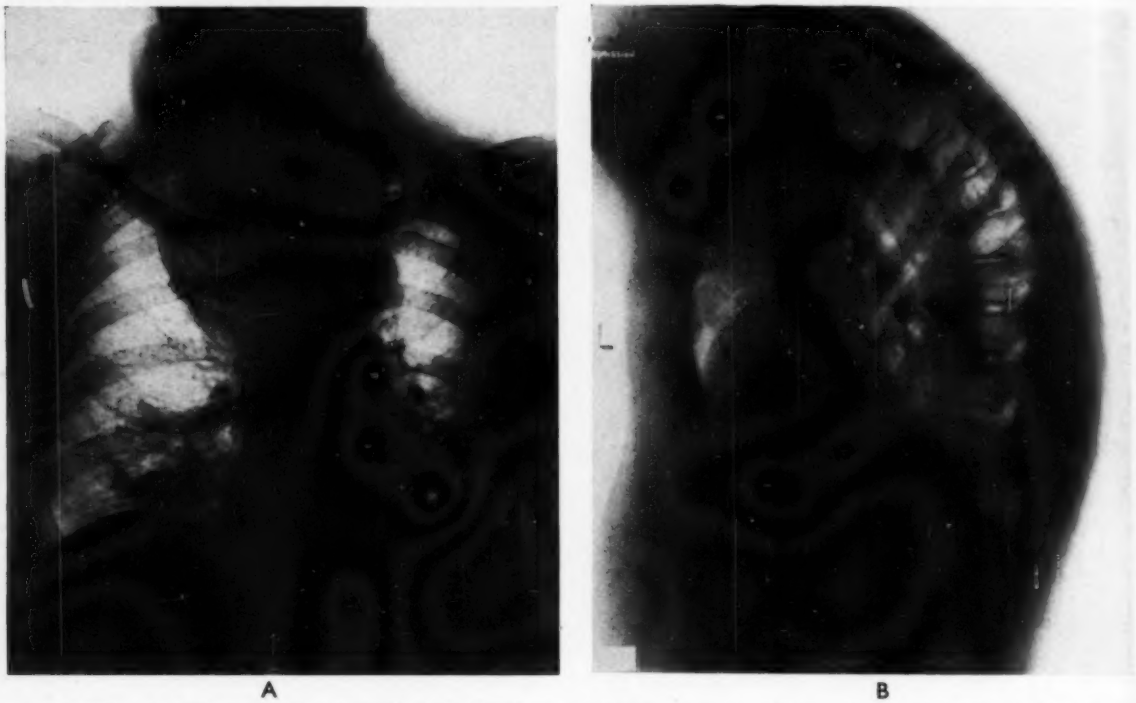
DIAGNOSIS

At times other lesions of the superior mediastinum (e.g., of the lungs, great vessels, œsophagus, or thymus) may radiologically be indistinguishable from an intrathoracic goitre.

The presence of a cervical goitre or a previous history of a thyroid enlargement or thyroidectomy are very suggestive of a mediastinal mass being an intrathoracic goitre. Typical radiological features of an intrathoracic goitre are displacement and compression of the trachea and movement of the mass on swallowing.

Investigations which should be carried out routinely are screening, barium swallow, tomography, laryngoscopy and bronchoscopy. Others, such as kymography, venography, cardio-angiography, cardiac

catheterization, or œsophagoscopy, may have to be done occasionally to exclude other conditions. Over a period of years in this clinic a wide variety of pathological conditions has occasionally been found to show radiological features difficult to distinguish from an intrathoracic goitre. These



A B

FIG. 360.—A, Anteroposterior radiograph of an intrathoracic goitre in a woman aged 73. At operation this proved to be malignant, but is indistinguishable radiologically from a benign goitre. B, Lateral view of same patient.

have included: bronchial carcinoma, innominate aneurysm, thrombosis of the superior vena cava, Hodgkin's lymphadenoma, ganglioneuroma, and pharyngeal pouch.

OPERATION

The operation for intrathoracic goitre has been described by many authors (Joll, 1932; Lahey, 1936; and others). There is some difference of opinion about the operative approach. It is suggested that a cervical incision with a sternal split if necessary is the approach of choice. This gives ready access to the blood-supply and makes it possible to do a partial or subtotal thyroidectomy. In 28 of our cases a cervical incision was used and in 3 of these a sternal split was added. Thoracotomy was carried out in 4 of our cases. Previous thyroidectomy has by some been considered an indication for thoracotomy. In 6 of our patients, however, who had had a previous thyroidectomy the cervical approach proved to be entirely satisfactory. Posterior mediastinal position of the goitre is not a contra-indication to the cervical approach. This incision was used without difficulty in 3 cases where the goitre was entirely in the posterior mediastinum. Thoracotomy should be reserved only for cases where the mass is low down in the thorax (*Fig.* 357) or where the diagnosis is uncertain.

The usual operative procedure was a subtotal resection of one or both lobes of the thyroid, including the intrathoracic extension. In 5 cases the intrathoracic goitre alone was removed. Usually there was some connexion with the thyroid gland in the neck; the mass was either arising directly from the thyroid gland or had a vascular or fibrous pedicle leading to it.

Post-operative complications included thrombosis of the deep calf veins (1 case), lower lobe atelectasis (2 cases), and bronchopneumonia (1 case). There were no deaths in the 28 benign cases; 2 of the patients with malignant goitre died two and nine days respectively after operation. One developed a hemiplegia and the other died of progressive dyspnœa.

SUMMARY

A review of 32 cases of intrathoracic goitre which were treated surgically is presented. In 28 patients the goitre was found to be benign and in 4 malignant. The symptoms, clinical findings, diagnosis, and operative approach are discussed.

My thanks are due to Mr. George A. Mason for permission to publish these cases; and to Dr. Whately Davidson for his help in the interpretation of the radiographs.

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OMENTAL TORSION
AS A SURGICAL EMERGENCY

By P. A. BOA, Sydney, Australia

This article deals with torsion of the greater omentum as a surgical emergency, implying not only a rotation of the structure about its long axis, but of sufficiently acute onset and to such a degree as to cause circulatory obstruction, resulting in strangulation—i.e., acute, complete omental torsion.

REVIEW OF LITERATURE

Omental torsion is a rare condition, the first case being recorded by Marchette in 1851, and since then approximately 250 cases have been recorded.

In 1905 Corner and Pinches compiled 51 cases from the literature to which they added 3 cases of their own. McWhorter (1928) recorded 26 cases, 2 of which were his own. Wakeley (1929) reported 2 personal cases, and Morris (1932) collected 164 cases, to which he added a further 4 cases. In 1945 Etherington-Wilson published 4 personal cases.

Aetiology.—The first full account of this condition was given by Morris in 1932, and, although he formulated a somewhat complicated classification, it would appear that all cases fall into one of two main groups, namely :—

1. *Unipolar* : The greater omentum hangs freely in the abdominal cavity, there being either no apparent pathology (idiopathic or primary omental torsion) or some condition resulting in increased density of the dependent portion, e.g., localized fibrosis or a tumour.

2. *Bipolar* : In these cases the distal dependent edge of the omentum becomes adherent to the inguinal or pelvic regions, thus forming a fixed axis about which the omentum rotates. In approximately 50 per cent of these cases the lower point of fixation is an inguinal or femoral hernia.

The most important single factor in the cause of omental torsion appears to be inhibited mobility of the dependent portion of this structure, whether it be relative, as in some cases of unipolar torsion, or absolute fixation, as seen in the bipolar variety.

But the factors are still unknown which bring about torsion in the idiopathic unipolar variety, and indeed, which initiate the rotary movement in all types. A considerable amount of speculation has been made on this subject, and it would appear that several factors play a part, the most feasible being :—

1. *Structural Characteristics of the Omentum.*—The right side of the omentum hangs lower and is equipped with two or more processes, whereas the left half is shorter and tucked under the left hypochondrium. As may be expected, therefore, torsion is almost confined to this right half, and it is in obese subjects when it is loaded with fat, that torsion is most commonly encountered (Morris' 'Torsion habitus').

Payr (1902) has pointed out that the omental veins are unusually long and tortuous, and, should they become engorged by the initial rotation, they may aid in completing the torsion.

2. *'Rifling Effect' of a Hernial Sac.*—Hadda (1910) suggested that successive herniations into a sac or irregular bore may give the necessary impetus to torsion, in a similar manner to a bullet travelling along the barrel of a gun. In favour of this theory is the fact that the majority of torsions are associated with a hernia.

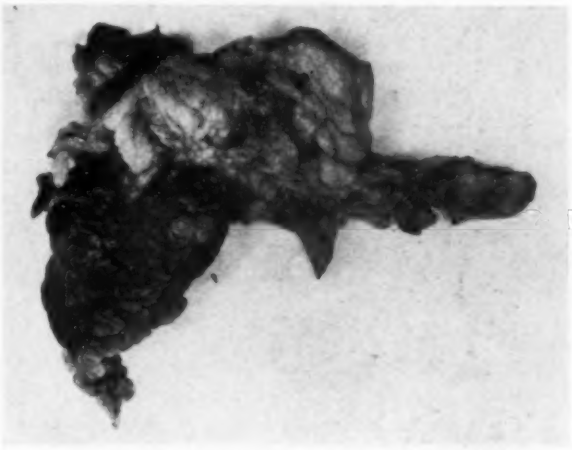

Fig. 361.—Unipolar omental torsion (idiopathic variety). Photograph of operation specimen showing normal omentum above, and heart-shaped gangrenous mass below, measuring 7 cm. in diameter. The point of torsion lies between the two areas.

3. *Postural Changes and Abdominal Trauma* have been cited as aetiological factors in several cases, but in the majority no such history is given.

CASE REPORTS

Both of the following two cases presented as an acute abdominal emergency, and are respectively examples of complete unipolar and bipolar torsions.

Case 1.—W. G., male, aged 59. Admitted Oct. 1, 1953, as acute appendicitis.

History.—Onset of constant aching pain in R.I.F. 48 hours prior to admission. Subsided after about 6 hours, but returned with added intensity on following day. Anorexia, but no vomiting. Normal bowel habits.

On Examination.—Slightly obese. Tenderness in R.I.F. No rigidity or guarding. Shifting dullness in flanks. No hernia. Leucocyte count 13,720.

Diagnosis.—Mild acute appendicitis.

At Operation.—Gridiron incision showed peritoneum to be œdematous. Free blood-stained fluid. Appendix normal and removed. Heart-shaped mass of gangrenous omentum 7 cm. in diameter lying free in R.I.F. and resected. Torsion through 360° had occurred close to the transverse colon. No other abnormality in the abdomen.

Convalescence was uneventful.

The Specimen.—Microscopical examination of specimen showed congestion and necrosis but no other pathology.

Comment.—Unipolar torsion of the true idiopathic variety (*Fig.* 361).

Case 2.—C. C., female, aged 64. Admitted Aug. 24, 1954, as torsion of an ovarian cyst.

HISTORY.—Six days prior to admission patient had experienced gradual onset of colicky, generalized abdominal pain becoming progressively more severe until admission. Anorexia but no vomiting. Absolute constipation and gradual increase in girth of abdomen since onset of pain. There was a history of recurring attacks

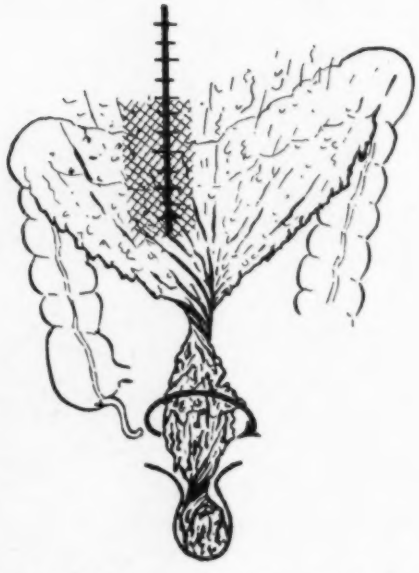

FIG. 362.—Bipolar omental torsion. Diaphragm showing torsion of greater omentum about a fixed axis, the points of fixation being adhesion to the old operation scar above and an adherent omentocele below.

of mild colicky pain over the past twenty-five years, accompanied by a ' burning ' sensation in the region of a right inguinal hernia. The latter had been present about forty years and had apparently never been reducible. T.P.R., normal. Cholecystectomy in 1949.

ON EXAMINATION.—Obese. Right upper paramedian scar and moderate distension. An irreducible right inguinal hernia, which was slightly tender and displayed no impulse on coughing. A vague tender mass was present in R.I.F. Shifting dullness could not be elicited.

DIAGNOSIS.—Subacute intestinal obstruction. It was decided to perform exploratory herniotomy.

AT OPERATION.—The indirect sac contained adherent gangrenous omentum twisted in the region of the neck of the sac. There was no obvious point of constriction, however, and laparotomy was decided upon.

The sac and contents were excised and herniorrhaphy carried out with stainless steel wire.

Laparotomy revealed further twists in the great omentum close to the transverse colon, where it was adherent to the old paramedian scar. About 8 in. of gangrenous omentum was excised.

Convalescence was prolonged by wound infection.

Comment.—Bipolar torsion had occurred between the paramedian scar above and the adherent omentocele below. The transverse colon was partially obstructed by kinking (*Fig.* 362).

DISCUSSION

In neither of the above cases was there any history of sudden postural change or abdominal trauma, nor did they exhibit rigidity, although the latter sign has frequently been observed in recorded cases. Nothing characteristic was noted in the type of pain. In both cases a vague tender mass could be felt in the R.I.F., and on reviewing the literature this seems to be the most constant and valuable physical sign.

Case 2 emphasizes the importance of demonstrating a definite point of constriction when operating on a strangulated omentocele. Otherwise, one may merely resect the distal fraction of a bipolar omental torsion. Such a mistake was reported by Demons in 1893.

Diagnosis.—In the cases recorded in the literature rarely has a correct pre-operative diagnosis been made. The conditions most frequently confused with acute complete omental torsion are acute appendicitis and appendiceal abscess, strangulated hernia, torsion of an ovarian cyst, acute cholecystitis, and perforated duodenal ulcer leaking into the right paracolic gutter. However, acute complete omental torsion should be taken into consideration when an obese patient with a right inguinal hernia complains of acute pain in the R.I.F. accompanied by a tender mobile mass in the right lower quadrant, especially in the presence of a right inguinal hernia.

SUMMARY

Acute complete omental torsion is rare.

1. The most important causative factor is an inhibited mobility of the dependent portion of the right side of the omentum.

2. A correct pre-operative diagnosis is rarely made. The most valuable physical sign is a tender mobile mass in the right lower quadrant of the abdomen. Inguinal hernia is a frequent accompaniment.

3. When operation is carried out for strangulated hernia, if the sac contains gangrenous omentum and there is no obvious point of construction, laparotomy should be performed, since bipolar omental torsion is probable.

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VISITS TO CLINICS

THE NEUROSURGICAL CLINIC AND THE NEUROLOGICAL LABORATORIES AT THE ROYAL INFIRMARY, MANCHESTER

UNTIL 1951 UNDER THE DIRECTION OF SIR GEOFFREY JEFFERSON, C.B.E., F.R.S., M.S., F.R.C.S., F.R.C.P.

"For the whole earth is the sepulchre of famous men; and their story is not graven only in stone above their native earth, but lives on woven into the stuff of other men's lives."

THE GENESIS OF THE MANCHESTER SCHOOL OF NEUROLOGY AND NEUROSURGERY

In a paper contributed to the *Manchester University Medical School Gazette* for June, 1948, on "Pioneers in Neurology", Sir Geoffrey Jefferson related the growth of the tradition he inherited as a student in Manchester, and which he has done so much to enhance. The trail was blazed by James Ross (1837–92), an Aberdonian, who came to Manchester as Pathologist to the Royal Infirmary, and subsequently was appointed as a Physician to the Royal Infirmary, and later Professor of Clinical Medicine at Manchester. In 1881 Ross published in two volumes a *Treatise on the Diseases of the Nervous System*. In 1886 he published, primarily for students, a *Handbook on Diseases of the Nervous System*. He had for some years been carrying out researches on the cause for pain being referred to the periphery from an apparently inert but diseased insensitive viscus, and in 1888 published his observations in a paper "Segmental Distribution of Sensory Disorders" (*Brain*, 1888). The conclusion he drew was that there are two types of pain, true splanchnic pain felt in the affected organ, and associated somatic pain referred by the cerebrospinal nerves to the body wall accompanied by cutaneous hyperæsthesia. This subject has been further elaborated in our day by Professor John Morley, the Emeritus Professor of Surgery of the University of Manchester. Ross was also fascinated by the subject of aphasia, and published no less than eleven papers on this topic and, in 1887, a book *Aphasia*, in which he analysed 10 cases which had been under his own care and critically reviewed the most important theories to explain the condition which had been advanced up to that time. His premature death prevented the completion of his researches on peripheral neuritis. These, however, were collected, and together with others written by his colleague Judson Bury, published in book form in 1893.

Julius Dreschfeld (1846–1907) the first Professor of Pathology to be appointed to Owens College in 1882, and incidentally the first Professor of Pathology to be appointed in England, was also interested in the central nervous system. In 1879 he published a paper in *Brain* on "Changes in the Spinal Cord after Amputation of the Limbs", he also carried out researches on the course of the visual fibres and described one of the earliest recorded cases of acromegaly. Dreschfeld investigated an outbreak of hydrophobia which occurred in Manchester during 1882–3 the results of which, if they had been published, would have anticipated the researches and conclusions of Louis Pasteur. He had the idea that the toxic agents lay in the spinal cord. He was

Geoffrey Jefferson.

Sir GEOFFREY JEFFERSON
C.B.E., F.R.S., M.S., F.R.C.S., F.R.C.P.
Emeritus Professor of Neurosurgery and lately Director of the Neurological Laboratories of the University of Manchester; Honorary Neurosurgeon to the Royal Infirmary, Manchester, (1926–46).

ultimately appointed Professor of Systematic Medicine in Manchester. George Arthur Wright (1851–1920) must be remembered for the book written in conjunction with Henry Ashby (1846–1908) on *Diseases in Children*, which had a world-wide circulation; but in 1888 he was the first to record the removal of a dumb-bell neurofibroma from the spinal cord.

It was in the same year that William Gowers, for the first time ever, localized an intraspinal tumour which was removed by Victor Horsley.

As early as 1903 Wright had advocated intraneural injection in the treatment of trigeminal neuralgia in a paper entitled "The Injection of Osmic Acid". It was about this period that Sir William Thorburn (1861–1923), a surgeon on the staff of the Royal Infirmary, Manchester, began his

Sir Geoffrey Jefferson in the ward.

pioneer work, before radiology was available, on the segmental distribution of the spinal nerves. In 1889 he published his classical paper, "A Contribution to the Surgery of the Spinal Cord". His work on the effects of the cervical rib and its treatment is known to all. Thorburn wrote no less than eighty-two papers, of which forty-six were concerned with neurology and neurosurgery. "He and Sir William Macewen were the two men outside London who made it plain that the central nervous system was a practical field for surgery." The articles he wrote in Burghard's *System of Operative Surgery* made his reputation as a pioneer in neurosurgery for all time. In 1908 another book came from the Manchester School on *Diseases of the Spinal Cord* by R. T. Williamson (1862–1937), in which he drew particular attention to the vascular supply to the cord, and in 1912 Dr. Judson Bury, an Honorary Physician on the staff of the Royal Infirmary, published his well-known monograph on *Diseases of the Nervous System*. With such a record it has been truly said by Sir Geoffrey that "no school and hospital in the country has had on its staff such a succession of pioneers in neurology and neurosurgery as that of Manchester except the specialist National Hospital in Queen Square".

THE EARLY PERIOD

Geoffrey Jefferson was born on April 10, 1886, his parents were both brought up in the medical tradition. His father was a medical man, educated at St. Thomas's Hospital, and a contemporary of the late Sir Charles Sherrington. His mother was a trained hospital nurse at York County Hospital. His father was a practitioner surgeon on the staff of the Rochdale Infirmary. His paternal grandfather and great-grandfather were officers in the Royal Navy, the latter being a midshipman under Bligh of the *Bounty* and was also present at the Battle of the Nile. Geoffrey's younger brother joined their father in practice and later became a consultant surgeon in Rochdale. His death just after he had been given the Freedom of the Borough has recently been mourned by his many friends, colleagues, and patients. Geoffrey was educated at the Manchester Grammar School, which has produced so many brilliant men who have made great reputations in business, industry, and professional callings.

He became a medical student in the Manchester School and qualified as an external student of the University of London with first-class honours and distinction in Surgery in 1909. He began to make his reputation very early in his student career by gaining the Sidney Renshaw Exhibition in Physiology at Manchester, and the London University Scholarship in Anatomy, which he shared with the late Bernard Maybury of St. Thomas's. After qualification he became house surgeon to Mr. George Arthur Wright and Arthur Burgess at the Royal Infirmary, Manchester. He became a Fellow of the Royal College of Surgeons of England in 1911, and was awarded the gold medal when he obtained the degree of Master of Surgery of the University of London in 1913. After his resident appointments in Manchester he became a Demonstrator in the Department of Anatomy in his school under Professor Sir Grafton Elliot-Smith and then began some research work on cortical function.

He himself has said: "Perhaps I learned from him the great good that one can do by apparently wasting one's time talking to associates, to the team, about this and that. The time though apparently wasted by the Chief was not so for them. It is an important duty for seniors." It was while working with Professor Sir Grafton Elliot-Smith that he made up his mind to make neurosurgery his career. However, he migrated to London for a time, becoming house surgeon to Sir Herbert Waterhouse, Joseph Cunning, and W. F. Fedden at the Victoria Hospital for Children, and later he worked with Ernest Miles and Jocelyn Swan at the Royal Cancer Hospital (now the Royal Marsden Hospital).

THE MIDDLE PERIOD

There seemed little hope of being able to make neurosurgery his vocation in this country, so in 1914 he went to Canada as there were prospects of a University with a medical school being founded at Vancouver in British Columbia. He was already engaged to be married to a Canadian lady medical student who was a protégée of Sir William Osler, who had given her the nickname of Trotula, after the famous woman surgeon of Salerno, and for whom he set the well-known examination paper in

Physiology. (*Life of Sir William Osler* by Harvey Cushing, vol. II, p. 203.) Osler suggested that they should be married from his house "The Open Arms", 13 Norham Gardens, Oxford, where they and many others were always so welcome.

Jefferson returned to England in 1915, and it is worthy of record that a medical school was not opened in Vancouver until 1950. In 1916 he joined up with the Anglo-Russian Hospital in Petrograd and Volhynia and while in Petrograd he operated upon some of the first casualties of the Russian Revolution who were wounded on the Nevski Prospekt outside the doors of the Palace of the Grand Duke Dimitri Pavlovich in which the base hospital was located. After fifteen months in Russia he proceeded to work in hospitals in France and elsewhere. After the war he worked at the Royal College of Surgeons with Sir Arthur Keith on some of the pathological material from battle casualties.

led him to investigate the anatomy and surface markings of the ventricular system, which is so important in making a diagnosis and prognosis in intracranial lesions. This was done before pneumography and it is safe to say that no one before Jefferson had such an exact knowledge of the ventricular surface markings, though the ventricles had been described and quaintly figured by Leonardo da Vinci (1452–1519).

Sir Geoffrey Jefferson with, *left* to *right*, Mr. G. K. Tutton, Mr. Richard Johnson, Mr. S. Dimant, two house surgeons, and Sister Martin.

In 1919 Jefferson was appointed to the Honorary Surgical Staff of the Salford Royal Hospital with Garnett Wright, James Macalpine, and Robert Ollerenshaw as colleagues. Wright was a general surgeon but Macalpine was a urologist, and eventually the author of a well-known book. Ollerenshaw was an orthopædic surgeon, and owing to the interest of each in a particular branch of surgery, the Salford Royal Hospital became one of the first general hospitals in the country to encourage each member of the staff to cultivate a specialty in surgery, which custom has now been copied by many others with advantage both to the staff and patients. Jefferson had had his interest aroused as to the possibilities of neurosurgery while still a student under Sir William Thorburn and when demonstrating Anatomy in Manchester. He had had an opportunity just before his appointment to Salford Royal of collecting a series of cases with penetrating head wounds and also the autopsy findings. These

It was while he was on the staff of the Salford Royal that he also began his researches on the lesions of the pituitary gland and the diagnosis and treatment of cerebral aneurysms.

In December, 1926, he was appointed to the Honorary Staff of the Royal Infirmary, Manchester, as the Neurosurgeon, with four beds, but in two years these were increased to six and later to eight. It was in this year that together with Sir Charles Ballance, Sir Percy Sargent, and Wilfred Trotter he founded the Society of British Neurological Surgeons and became the Honorary Secretary and remained as such for many years even when he was President. It was due to this Society that when war came in 1939 the organization of the methods of dealing with war casualties involving the central nervous system was so much better and more successful than that in use in the 1914–18 war.

His work increased to such an extent that in 1932 he was given charge of twenty-four beds and shared a specialized Unit in the hospital with Sir Harry Platt, the present President of the Royal College of Surgeons of England, who had also been appointed to the Honorary Staff as the Orthopædic Surgeon.

The University later created special Professorial Chairs for both Sir Geoffrey Jefferson and Sir Harry Platt in their respective specialties.

Jefferson's reputation as a neurological surgeon had increased to such an extent throughout the years that in 1933 he was invited to join the Honorary

Staff of the National Hospital for Nervous Diseases in Queen Square, London. He paid a fortnightly visit there of one or two days, and continued to do so until early in 1939. If the war had not threatened he would probably have accepted an offer, mainly through the influence of the Rockefeller Foundation, to remain permanently in London. With this background there was a gradual realization and recognition by his colleagues in Manchester, and wherever else, both in this country and all parts of the world, where modern surgery is practised, that Geoffrey Jefferson was not only maintaining the tradition of the Manchester School of Neurology which he had inherited, but adding to it, by developing a school of Neurosurgery, influenced by that of Harvey Cushing's in Boston, but essentially of his own formation.

The old Board of Management of the Royal Infirmary, Manchester, recognized this when they placed on one side a bequest of £96,000 by Mr. Fielden " to give the University Units in the Royal Infirmary working conditions such as might assist them in good and productive work ". The project gradually came to fruition as the Board realized that " however much a hospital was a teaching hospital, with the strongest University links, it still had a function which was primary and anterior to its educational commitments, namely, the provision for the patient within its walls of as good specialist services as possible ".

LATER PERIOD

On May 3, 1950, one of the greatest ambitions of Jefferson's life was realized when the newly constructed department of Neurosurgery was opened at the Royal Infirmary by his friend Lord Alfred Webb-Johnson, Past President of the Royal College of Surgeons of England, himself a Manchester student and graduate in 1903, with first-class honours, of the Victoria University, which at that time included as one of its constituent University Colleges that of Manchester. Jefferson had been planning such a department for many years but it only came to fruition one year before he had to retire in 1951 from the Professorial Chair on age limit.

The department embodies all that at present is necessary for the thorough investigation of diseases of the central nervous system. It is complete with wards, a neuro-radiological department, and rooms for research laboratories and special investigations of patients. The provision in every big hospital of adequate means for research and utilization of the opportunities which clinical practice affords for observation in applied physiology would meet one of the great needs of the present day.

A neurosurgical clinic to be efficient must have its own specially arranged neuro-radiological unit in close proximity to the operating theatre because of the special investigations which have to be made, such as ventriculography, myelography, percutaneous angiography, and now a Geiger counter so that isotopes can be used during operative procedures to localize tumours. Provision must also be made for the accommodation of an electroencephalographic machine for electrocorticography investigations. The excellent arrangements in the neuro-radiological unit in Manchester are due to the forethought and expert knowledge of Dr. Eric Gray and of Dr. R. G. Reid the Director of the Department of Radiology at the Royal Infirmary.

A recent survey in his department showed that the number of patients who attended for investigation from the neurosurgical unit was not more than one-tenth of those attending on one day, yet they accounted for rather more than one-quarter of the available time. This emphasizes the importance of a neurosurgical clinic having its own neuro-radiological unit.

Sir Geoffrey Jefferson operating on an aneurysm, assisted by Mr. S. Dimant.

The whole of the neurosurgical unit is liberally supplied with research rooms, laboratories, office facilities, and storage space for records and films. The retiring rooms for sisters and nursing staff are restful and attractively furnished.

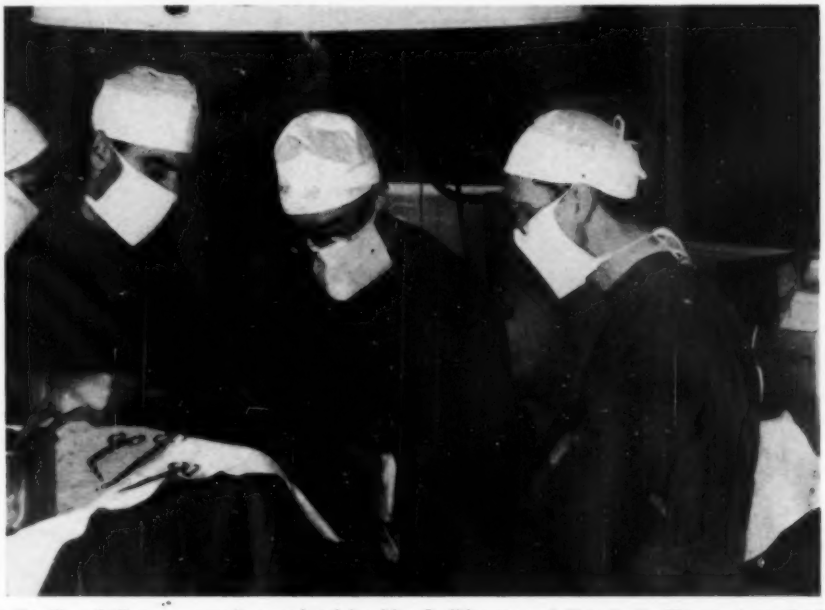
The accommodation for visitors in such a unit is important as postgraduates do, and will continue to come from all over the world to spend time and seek opportunity to work and learn in Jefferson's clinic.

The trained assistants in the unit include in addition to sisters, nurses, and orderlies, such members as almoners, home visitors, and advisers to the relations of the patient during the post-operative and convalescent period. Others are available who can advise and if necessary help in some of the details of home management, to assess the extent of the disablement, and the patient's working capacity. The records must be complete and absolutely accurate.

THE PRESENT PERIOD

Though no longer actually in charge of the department Sir Geoffrey Jefferson is welcomed in it by his successor, Mr. Richard T. Johnson, who, hand-picked by his late chief, was his University Lecturer and Assistant Surgeon for four years.

As one enters the Unit with him the word seems to go round "Jeff has arrived" and the congregation gathers around him from all sides. It is a privilege to go round and hear the discussion between the present Director and his late chief as to the diagnosis of a case, the best method of further investigation, and appropriate treatment. The case on which Jefferson was to operate the following morning was fully discussed, the results of all the ancillary aids to diagnosis were checked, X-ray films were examined, the patient was approached with that tactful kindliness and understanding which constitutes the art of clinical medicine and cannot be taught, but is only learnt by experience and refined by the humane and unassuming, after years of practice. It all appeared so easy and obvious to diagnose the exact position of the small aneurysm on the middle cerebral artery which was confirmed and dealt with next morning by the superb technique and ease of execution which one associates with a master.



Sir Geoffrey Jefferson operating, assisted by Mr. S. Dimant and Dr. A. R. Hunter (anæsthetist).

The illustrations which accompany this account of the Unit are self-explanatory and help to convey the efficiency and happy atmosphere of the clinic which is being so well run by the present Director.

The amount of work done in a modern neurosurgical clinic is illustrated by the figures from Manchester. During the period 1927–31 there were 300 operations; in the period 1947–51 no less than 2539. In the period 1927–50 there were 2507 tumours of the brain operated upon. Between 1919 and 1938 Jefferson had done 277 root sections for trigeminal neuralgia and now (1954) the figure has reached 600, with 2 deaths, and more than 1000 cases have been treated by injections.

The Present Need for Adequate Neurosurgical Units.—The figures speak for themselves, and no one interested in arranging and organizing an adequate service to meet the needs of the general population can be complacent until they are met more thoroughly than at present. The Planning Committee of the Society of British Neurological Surgeons considered the need for such Units over the whole country in 1945–7 during the presidency of the late Sir Hugh Cairns. They came to the conclusion that a Neurosurgical Unit of at least fifty beds is necessary to cope with the needs of every million of the population, with two or three surgeons, assistants, and ancillary staff in each. They estimated that 30 per cent of all head injuries caused by transport or industrial accidents need operative treatment of one kind or another. The need for segregation of head injuries in a special neurosurgical unit is well illustrated by comparing the results of treatment of battle casualties in the two world wars. The same reasons support the conclusions of the Society of British Neurological Surgeons concerning the need for special units to be organized on a regional basis for the general population. The experience of various surgeons in the treatment of the battle casualties from the 1914–18 war is recorded in volumes V, VI, and VII of this journal. The two most important reviews are those by Harvey Cushing (*Brit. J. Surg.*, 1918, 5, 558–684) and Geoffrey Jefferson (*Brit. J. Surg.*, 1919, 7, 262). The salient facts which stand out in these are, that the sooner treatment is commenced after the infliction of the wound the better the prognosis; the first treatment, as in all other conditions demanding surgery, is the all-important one; sepsis must be prevented and this is mainly done by adequate surgery, which prevents a contaminated wound leading to bacterial invasion of the tissues. The use of antiseptics and antibiotics is not a substitute for adequate surgery, and under proper conditions the

brain, like other living tissues, will carry out its own repairs.

The published statistics confirm these conclusions. In June, 1947, this journal published the first Supplement on War Surgery which was devoted to "Wounds of the Head". The articles by the various neurosurgeons justified all the planning by the late Sir Hugh Cairns, who had been appointed consultant in neurosurgery by the War Office during the years between the wars, and Sir Geoffrey Jefferson also was made responsible for the neurosurgical arrangements of the Emergency Medical Service. The article by Sir Hugh Cairns in the Supplement sums up his conclusions as to how the astounding results were achieved of reducing the mortality of penetrating wounds from 36·7 per cent to 5 per cent, and non-penetrating to less than 1 per cent. These were segregation of the cases; air evacuation in all theatres of war whereby 90 per cent of patients were in the hands of surgeons in time to have the wounds closed after adequate toilet, 80 per cent of which healed by first intention; and properly trained neurosurgeons, nurses, and assistants. The ancillary factors were the competence and enthusiasm of Neurologists, Bacteriologists, Pathologists, Anæsthetists, and Plastic Surgeons; the new antibiotic penicillin; resuscitation methods, including blood transfusion; the technique of electrocoagulation; and power suction. The War Office had appointed the late Sir Hugh Cairns as consultant to the Queen Alexandra's Military Hospital, Millbank. At Oxford there was a neurological hospital—Military Hospital (Head Injuries)—of 300 beds, known as 'St. Hugh's', which treated some 13,000 Army, R.A.F., R.N., and allied patients between February, 1940, and September, 1945, and also provided training for neurologists, neurosurgeons, nurses, and orderlies, who were later drafted into neurosurgical teams and posted to various battle areas.

Sir Geoffrey Jefferson with, *left* to *right*, Mr. S. Dimant, Dr. R. G. Reid, Dr. Clive Moss, Mr. K. Norcross (house surgeons), Mr. G. K. Tutton, Sister Kearson, Mr. Richard Johnson, and Sister Martin.

It is impossible in an article such as this to give any account of the succession of papers which have come from the Manchester Neurosurgical Unit, nor is the writer capable to do so. They cover a wide range of subjects which have influenced the trend of neurology and neurosurgery all over the world. They include articles embodying the results of research on the cerebral localization of function, trigeminal neuralgia, tentorial pressure cases and their relationship to unconsciousness, pituitary tumours, localization of cerebral aneurysms and carotid ligation, cervical spinal injuries, encephalography, and temporal lobe epilepsy, the technique for various neurological investigations, and operative procedures for the relief of mental disorders. Many of these have been published in this journal and will be known to its readers.

AS OTHERS REGARD HIM

How have Geoffrey Jefferson's colleagues, friends, and pupils shown their appreciation of all that he has done with others, most of whom belong to Harvey Cushing's " devoted band of pupils ", to place neurosurgery on a sound basis? There must have been in the past many opinions expressed in letters, speeches and private conversation which have conveyed to him the esteem, affection, and gratitude with which he is regarded, but such are private. The only public way has been to confer on him numerous honours and distinctions such as few have received. The two greatest honours which he has received, and which must have thrilled and moved him deeply, are the election to be a Fellow of the Royal Society in 1947, a very rare honour and distinction to be conferred on a surgeon, and his selection to receive the Lister Medal and deliver the Lister Oration on " The Mind of Mechanical Man " on June 9, 1949, at the Royal College of Surgeons of England.

The Lister Medal is the greatest honour that any surgeon can receive from his scientific and surgical colleagues. " The Lister Memorial Fund was raised by public subscription with the object of showing a lasting mark of respect to the memory of the Right Honourable Lord Lister of Lyme Regis, O.M., F.R.S., F.R.C.S., in grateful appreciation of his eminent services to the science of surgery and the signal benefit thereby conferred on mankind." " In 1920 the Royal College of Surgeons of England undertook to become the Trustees and Administrators of the fund—the trust was transferred to the College subject to the following provisions " :—

" That out of the General Fund " a monetary prize and " a bronze medal is awarded every three years, irrespective of nationality, in recognition of distinguished contributions to surgical science, the recipient being required to give an address in London under the auspices of the Royal College of Surgeons."

The award is made by a Committee of seven, made up of two members nominated by the Royal Society and two by the Royal College of Surgeons of England, and one member, each representing the Royal College of Surgeons of Ireland, the University of Edinburgh, and the University of Glasgow.

The extent and nature of the Honours and Distinctions which in addition to the above have been conferred upon him can be judged by the following list :—

Degrees and Diplomas :—

1946—Honorary Fellow of the Royal Faculty of Physicians and Surgeons of Glasgow.
1947—Master of Surgery (*Honoris Causa*) University of Dublin.
Honorary Fellow of the Royal College of Physicians of London.
1948—Doctor of Laws (*Honoris Causa*) University of Glasgow.
1949—Honorary Fellow of the British Orthopædic Society.
1950—Honorary Fellow of the American College of Surgeons.
1953—Honorary Fellow of the Royal College of Surgeons of Ireland.

Distinctions :—

1932—Saville Orator.
1939–40—President of the Neurological Section of the Royal Society of Medicine.
1940—President of the Society of British Neurological Surgeons, of which he was a founder member in 1926 and Honorary Secretary for many years.
1945—Awarded the Doyne Medal at the Ophthalmological Congress at Oxford.
1948—The Macewen Lecturer in Glasgow.
The Marnoch Lecturer in Aberdeen.
1950—The Franklin Martin Lecturer at Boston.
The Balfour Lecturer at Toronto.
The Sommer Lecturer at Portland, Oregon.
1951–52—President of the Association of Surgeons of Great Britain and Ireland.
1952—The Godlee Lecturer at University College, London.
1953—The Sherrington Lecturer at the University of Liverpool.
The Bowman Lecturer before the British Ophthalmological Society of the United Kingdom and recipient of the Bowman Medal.
The Elsberg Lecturer at New York.
1948–53—A member of the Medical Research Council and Chairman of the Clinical Research Board.
1955—The Hughlings Jackson Medal.
The Sheen Lecturer at Cardiff.
The Thomas Young Lecturer at St. George's Hospital.

He is also a Past President of the Medical Society, Pathological Society, and Surgical Society of Manchester, and an Honorary Fellow of the British Orthopædic Association.

Honorary Membership of the following Societies :—

The Medical Association of Sweden.
The Medical Association of Spain.
The French Academy of Surgery.
The Society of Neurology of Paris.
The American Neurological Association.
The American Neurosurgical Society.
The Harvey Cushing Society.
The Neurosurgical Societies of Scandinavia, Holland, France, Spain, Australia, and India.
The Neurological Society of Philadelphia.

It should be obvious from consideration of the foregoing, and be a matter for justifiable pride, that it is due to the work of Sir Geoffrey Jefferson and other neurologists and neurosurgeons encouraged and helped by those working in many different medical specialties, together with the devoted co-operation of nurses and many ancillary helpers, that Macbeth's words are being so amply justified :

> . . . The times have been
> That, when the brains are out, the man would die
> And there an end ; but now they rise again.
> *Macbeth*, III, 4.

The author is indebted for the photographs to Dr. R. G. W. Ollerenshaw, the Director of the Department of Medical Illustration, The Royal Infirmary, Manchester.

In Memoriam

SIR D'ARCY POWER, K.B.E., F.R.C.S.
(1855–1941)

NOVEMBER 11, 1955, is the hundredth anniversary of the birth of Sir D'Arcy Power. He died at an advanced age only 14 years ago, so that his memory is still green in the minds of many of us, and it is

SIR D'ARCY POWER, K.B.E., F.R.C.S.

appropriate that this anniversary should be observed in the pages of the journal which he did so much to foster.

Sir D'Arcy Power was born in London, the son of Henry Power, an eminent ophthalmic surgeon, and derived the name of D'Arcy from a military friend of his great-grandfather, Lt.-Col. Francis Power. He wrote a full account of his own life, on which was based the biography in the recently published volume of *The Lives of the Fellows*, so that it is unnecessary to recapitulate the facts in any detail. It will be better on this occasion to recall his personality and the impression that he made on his contemporaries.

Power was trained in surgery in the early days of Listerism and belonged, therefore, to a different tradition from that practised in the operating theatres of to-day. His methods were rapid rather than refined, and opening the abdomen with one stroke of the scalpel was deliberate policy rather than a love of 'showing off'. He was a pioneer in abdominal surgery and is reputed to have performed the first operation for gastro-enterostomy done in this country; he also, no doubt, held the record for speed in its performance. But in spite of an appearance of slap-dash technique, his results were very good, and the patients at St. Bartholomew's had every reason to be well satisfied with their treatment at his skilful hands.

He had a natural facility in writing, and from 1893 to 1927 he was responsible for a number of surgical works. It is customary, however, to predict that his name will live mainly in the biographical and bibliographical writings. His output on the historical side was, indeed, prodigious, and his long series of articles on *Epoch-making Books in British Surgery* and on eponyms were an important feature of the BRITISH JOURNAL OF SURGERY over several years. To mark his 75th birthday in 1930 an issue of the JOURNAL was dedicated to him, and a delightful volume of his *Selected Writings* served to remind his friends of the wide range of his interests and the fertility of his mind.

Sir D'Arcy contributed largely to the *Dictionary of National Biography*, and to Plarr's *Lives of the Fellows* of the Royal College which he served so well as Councillor, as Vice-President, and finally as Honorary Librarian. His *Life of William Harvey*, published in 1897, and his *Short History of St. Bartholomew's Hospital*, 1923, are still standard works. His immense industry, both surgical and literary, was not coupled, as might almost have been expected, with a solemn or dry-as-dust personality. On the contrary, he irradiated cheerfulness, kindliness, and a desire to help his fellows, though he could speak with biting sarcasm when he thought such treatment would be salutary. His friendship was a precious possession, and was often given without condescension to colleagues much younger than himself. With characteristic absence of affectation or pomposity, he could be seen moving about London, even in old age, on a bicycle, wearing homely clothes and with a cloth cap on his head. His name will be held in affectionate memory as long as there remain alive any of those that were privileged to know him.

SHORT NOTES OF RARE OR OBSCURE CASES

MYXOMA OF THE MANDIBLE

By A. C. BREWER and J. H. JOHNSTON
LIVERPOOL ROYAL INFIRMARY

Central myxoma of the jaw is a rare tumour. Thoma and Goldman (1947) were able to collect a series of 11 cases. In all except one of these a tooth was missing or embedded. The following example is of the very rare type where no dental abnormality is associated.

CASE REPORT

Miss V. M., aged 24, complained in June, 1951, of a painful swelling in the left side of the lower jaw which had been present for three months and was slowly increasing in size. The premolar teeth had been removed for caries. She had had no other dental treatment or extractions in the affected region.

Fig. 363.—Radiograph of the tumour.

On Examination.—There was a smooth, hard, ovoid enlargement of the left body of the mandible over which the soft tissues moved freely. A radiograph (*Fig.* 363) showed a multilocular cystic tumour which was considered to be either an osteoclastoma or an adamantinoma. No tumours were found elsewhere in the skeleton and the blood chemistry was normal.

At Operation (June 26, 1951).—An incision was made into the swelling from within the mouth. Soft mucoid material was curetted out and the resulting cavity packed.

Histological examination of the specimen showed replacement of the marrow by a relatively acellular myxoma.

Eight months later the tumour was found to have recurred in the original site. It was considered that resection of the mandible was necessary. Dental clearance of the left side of the mandible was carried out. The gums were given a period of six weeks to heal. Cap splints were fitted to the teeth of the maxilla and the remaining mandibular teeth. It was decided to use fixation by an external bar fitted to these caps, the proximal fragment being controlled by pin fixation.

Fig. 364.—Photograph after operation, showing extra-oral splintage.

Second Operation (May 9, 1952).—The pins were placed in position in the proximal fragment and the external carotid artery was ligatured in continuity through an incision at the anterior border of the sternomastoid. (It is now thought that ligation of the external carotid is not necessary.) Through an external skin incision the

mandible was resected from the right incisor teeth to the junction of body and ramus. This was carried out as an extra-oral procedure, the mucous membrane of the mouth not being opened. A graft was then taken from the subcutaneous surface of the left tibia and fitted as an inlay. The wound was closed without drainage; splintage was applied (*Fig.* 364).

Eight weeks after operation the extra-oral bar and pins were removed and five weeks later, when the radiograph showed sound union of the graft, the cap splints were taken off. Dentures were subsequently fitted.

FIG. 365.—Radiograph of the mandible seventeen months after operation.

FOLLOW-UP.—The patient shows no recurrence of her tumour and complains of no disability. The cosmetic effect is excellent.

Fig. 365 shows the X-ray appearance seventeen months after operation.

PATHOLOGY.—The specimen (*Fig.* 366) consisted of a nodular, gelatinous tumour measuring 5·5 × 3·5 × 3 cm. Histological examination after decalcification showed a myxoma spreading in the marrow spaces of the jaw. There was no evidence of malignancy.

DISCUSSION

Myxoma is a soft, gelatinous tumour which, histologically, consists of branching stellate cells in a loose, mucoid, basophilic stroma which may be finely fibrillated or granular. The tissue resembles embryonic mesenchyme and has its prototype in Wharton's jelly of the umbilical cord. The tumour is regarded by Willis (1948) as a variant of fibroma in which there is reversion to embryonic type. As in the case of fibrous tumours it may be impossible to distinguish histologically between benign and malignant forms. Myxomatous tumours of this type, as distinct from mucoid degeneration in chondromas or lipomas where cartilaginous or adipose tissue is recognizable, are usually unencapsulated and have a tendency to infiltrate. In the absence of wide excision this renders them particularly liable to recur after operative removal and eventually to metastasize.

Myxoma may originate in any mesodermal tissue. In bone it may form in the periosteum or, starting centrally in the medullary cavity, erode and expand

FIG. 366.—Photograph of the specimen.

the cortex. Thoma and Goldman (1947) consider that the central myxoma of the jaw differs from those elsewhere in the skeleton in being invariably benign. Because of the frequent inclusion of an unerupted tooth they regard it as of odontogenic origin, arising from the mesenchymal parts of the tooth germ, the dentine papilla, and the dental follicle. The tumour is thus related to the fibrous odontome.

Clinically, central myxoma of the jaw occurs most commonly in the second or third decades and leads to a painful swelling of the maxilla or mandible. It is usually associated with unerupted or congenitally missing teeth. Radiography shows a radiolucent area of bone of honeycomb or trabeculated appearance resembling osteoclastoma or adamantinoma. If an unerupted or partly developed tooth is present dentigerous cyst is simulated.

The tumour is not radio-sensitive. If small it may be treated by local excision or enucleation. If the bone is extensively involved and destroyed, or if the tumour recurs, resection of the jaw is necessary. In the case of the mandible immediate autogenous bone-grafting gives a good cosmetic and functional result.

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A SUPERNUMERARY LUNG

By GRAHAM E. SCHOFIELD

FORMERLY OF DEPARTMENT OF SURGERY, UNIVERSITY OF EDINBURGH

Ectopic masses of pulmonary tissue are not uncommon. They occur most frequently in the lower thorax and upper abdomen, and more rarely they are situated in the pleural dome or root of the neck. It is extremely rare for them to occur elsewhere.

Those of the cervico-thoracic group are almost invariably situated on the right side. The ectopic mass consists of well-developed pulmonary tissue having a bronchial communication with the trachea (Freedlander and Gebauer, 1939; Hulse and Curtis, 1940). In only 1 case, reported by Cotton, Spaulding, and Penido (1952), has the mass been subdivided into three distinct lobes, and in this case it was situated in a separate pleural cavity. The blood-supply in this and in all cases where it has been investigated has been derived from a systemic artery, either the innominate or the subclavian.

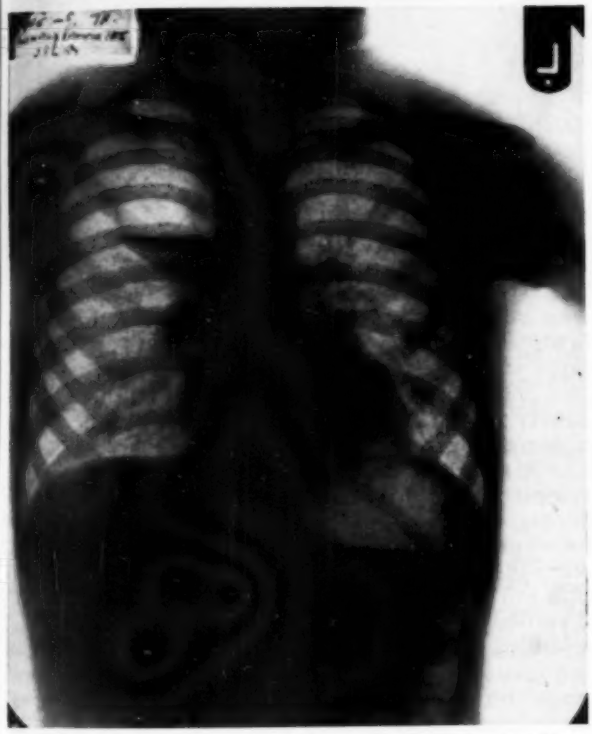

Fig. 367.—Radiograph of chest showing cyst of right upper lobe and supernumerary lung (anterior to right pulmonary hilum).

In recent years considerable attention has been paid to the ectopic pulmonary masses occurring in the lower thorax (Pryce, 1946; Pryce, Holmes Sellors, and Blair, 1947). They are usually situated within the posteromedial quadrant of either lower lobe or between the left lower lobe and the diaphragm. Their structure resembles that of normal lung, but they are often the site of disease (Pryce, 1946). They do not usually have a bronchial communication, although the intrapulmonary type may communicate with the adjacent lung through alveoli or cysts. Both types derive their blood-supply from a systemic artery, usually the lower thoracic or upper abdominal aorta.

CASE REPORT

A boy, aged 4½ years, was referred to a laryngologist because he was unable to speak properly. No cause for this was found, but because of a sternal deformity, his chest was radiographed, and on account of the radiological finding he was referred to the Thoracic Unit, Edinburgh.

There was no history of respiratory disease, and at the time of examination he had no respiratory symptoms. There was some flattening of the right side of the chest, and depression of the lower end of the sternum. There were no other relevant clinical findings.

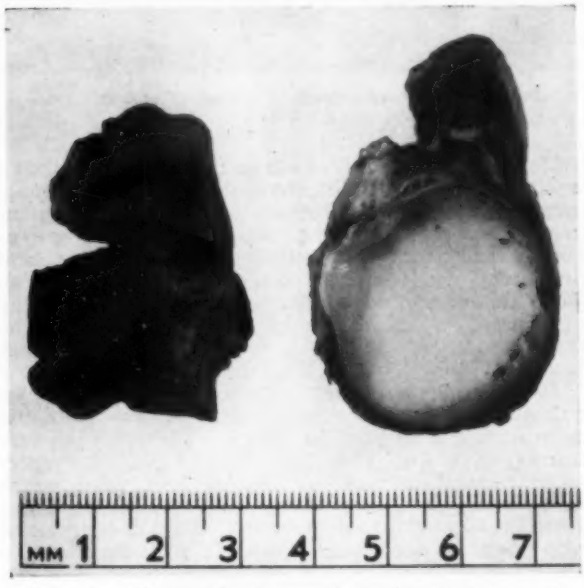

Fig. 368.—Photograph of resected specimens of cyst and supernumerary lung.

Radiologically there was a circular translucency 4 cm. in diameter, situated anteriorly in the right upper lobe, and containing a fluid level (*Fig.* 367). The Mantoux test was negative, and tubercle bacilli were not found in gastric washings, either on concentration or culture. At bronchoscopy the right upper bronchus was found to be directed downwards, so that all three segmental orifices within it were directly visible. The larynx, trachea, and other bronchi were normal. Bronchograms showed downward displacement of the right upper brochus. All the segmental bronchi were present, and no other abnormality was demonstrated.

A provisional diagnosis of congenital pulmonary cyst was made, and because of the danger of infection, resection was advised.

At Operation.—Right thoracotomy was performed (Mr. A. Logan), and the upper lobe was found to be densely adherent to the chest wall. After mobilization, the apical segment was seen to be partially separated from the rest of the upper lobe by a deep horizontal fissure, and to be divided by a shallow vertical fissure. The

anterior subsegment was entirely cystic, and had its own blood-supply from a vessel arising direct from the right pulmonary artery; its vein drained into the upper pulmonary vein near its termination. The rest of the right lung looked and felt normal.

Lying on the pericardium at the level of the upper pulmonary vein, and attached to the mediastinum by a pedicle 5 cm. long, was a structure which resembled a miniature right lung, 4 × 2 × 2 cm. in size. It was

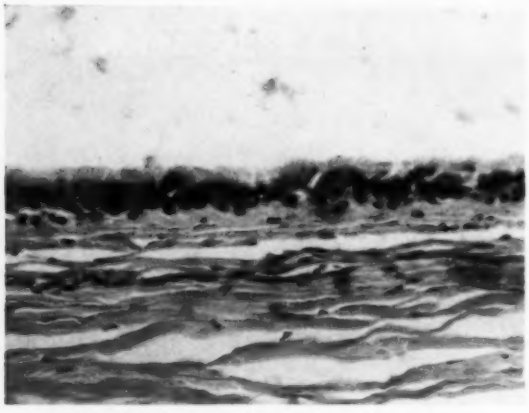

FIG. 369.—Photomicrograph of section of wall of cyst. (× 266.)

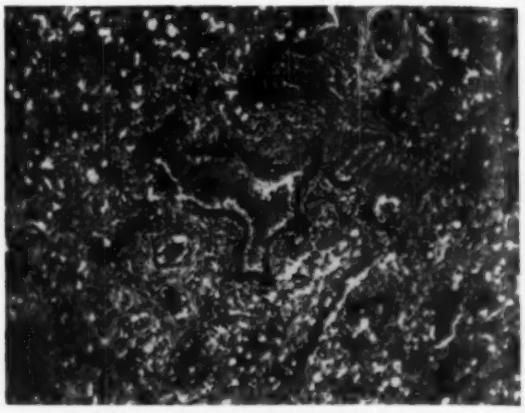

FIG. 370.—Photomicrograph of section of supernumerary lung. (× 66.)

divided into three lobes, of which the upper contained a small cyst. It derived its blood-supply from the upper branch of the right pulmonary artery, and its venous drainage was to the upper pulmonary vein. No macroscopical evidence of a bronchial structure was seen, and it was not closely connected to the right bronchus. Both the cystic subsegment of the right upper lobe and the supernumerary lung were resected (*Fig.* 368). The patient's convalescence was uneventful, and he was discharged home fourteen days later.

Histological examination showed the wall of the cyst to consist of loose fibrous tissue lined by ciliated columnar epithelium, multilayered in places. The contents were entirely mucoid in character (*Fig.* 369). The supernumerary lung consisted of normal lung tissue which was partially but not completely collapsed. Many alveoli contained blood and plasma. Several bronchioles and small bronchi were present, and contained a quantity of secretions. No larger bronchi were visible (*Fig.* 370).

It was thought that the partial dilatation of the bronchi was due to retained bronchial secretion, most of which had been washed out during the preparation of the section. It was unlikely that the alveoli had ever been aerated, in view of the thickness and shape of their walls.

DISCUSSION

It is now generally accepted that ectopic masses situated in the lower thorax arise by sequestration from the neighbouring lower lobe, and it is thought that the sequestration results from persistence of the primitive systemic blood-supply (Pryce, 1946; Pryce and others, 1947; Brewer, Clagett, and McDonald, 1950).

It is not nearly so clear how masses situated in the upper part of the thorax or root of the neck arise. It is possible that, like the more common variety, they arise by sequestration, and the fact that they have a systemic blood-supply may support this theory. But, unlike the more common variety, they have a bronchial communication with the trachea. However, there would not appear to be any reason why a sequestrated mass should not retain a bronchial communication; this probably depends on the site and time of sequestration. In this case one would expect to find an associated deficiency of bronchi in the neighbouring lung. Unfortunately, most of the cases described in the literature have been discovered incidentally at autopsy, and the anatomy of the adjacent lung has not been fully investigated. In the case reported by Cotton, Spaulding, and Penido (1952), the adjacent right lung consisted of two lobes only, which suggests that the ectopic mass in their case represents a sequestrated right upper lobe subdivided into three segments, and not a supernumerary lung.

On the other hand, the abnormal position of the ectopic masses may determine their abnormal blood-supply, and thus they may represent supernumerary lobes or lungs. Their bronchus usually originates from the right aspect of the trachea near its bifurcation. This is also the usual site of origin of tracheal diverticula, which are more common than the so-called tracheal lobes. Does this outgrowth represent a division of the tracheal bud into three main bronchi or a supernumerary right upper bronchus? Phylogenetic considerations favour the latter, because a second right eparterial bronchus is frequent in celaceans and other mammals, and occasionally occurs also in man when it supplies a normal right upper lobe (Gruenfeld and Gray, 1941). Thus the ectopic mass is more likely to represent a supernumerary lobe than a lung.

The case here presented is unusual in that the ectopic mass had a pulmonary blood-supply, and was clearly subdivided into three lobes resembling a miniature right lung. Apart from the presence of a cyst, the anatomy of the neighbouring lung was normal. These facts make it very unlikely that the mass arose by sequestration, and it would seem justifiable to claim that it represents a true supernumerary lung.

The occurrence of cysts in the upper lobes of both the normal lung and the supernumerary lung is interesting, but its significance is unknown.

SUMMARY

The anatomy and genesis of ectopic pulmonary masses are briefly reviewed.

A case is described of an ectopic pulmonary mass situated in the right hemithorax, with coincidental cyst of the right upper lobe, in a boy of 4½.

It is thought that most ectopic pulmonary masses arise by sequestration, although the so-called 'tracheal lobes' may represent supernumerary lobes or lungs.

The case presented is thought to be a case of a true supernumerary lung.

I wish to thank Mr. Andrew Logan for kindly allowing me to publish this case, and for his help in the preparation of the paper.

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STRANGULATION OF AN ULCERATED INCISIONAL HERNIA

BY P. D. O'DONOGHUE
ST. PAUL'S HOSPITAL, LONDON

THE case described here is considered unusual and interesting enough to appear worth recording.

CASE REPORT

Mrs. E. S., an extremely obese woman of 56, was escorted by a friend into the Casualty Department with the story that, six hours previously, " something that felt like intestines " appeared on the lower reaches of her abdominal wall. Two hours later she developed colicky abdominal pain which, however, had completely disappeared by the time of her arrival at hospital. She stated that the area felt tender, but because of her obesity, she was unable to see what was happening.

Thirteen years previously she had undergone some gynæcological procedure, soon after which she had developed a bulge to the right side of her scar, and the former had grown steadily in size since that time.

ON EXAMINATION.—Examination revealed an extraordinary state of affairs. The whole of her lower abdomen, which was sufficiently pendulous to cover her pubis, was, in effect, a vast hernial sac probably containing, when she was standing, the greater part of her small intestine. The sac appeared to arise originally from a site lateral to the old operation scar, which was displaced far over to the left. The splayed and attenuated edges of her recti muscles were palpable, on each side, in the regions of her anterior superior iliac spines.

Bulging from the most dependent visible area of the skin of the abdominal wall was a loop of frankly gangrenous small bowel about 6 in. in length, strangulated by a circle of hard and intensely thickened skin, which was completely rigid and resistant to the finger. The appearances were those of a long-standing deficiency remotely analogous to the thickened and dilated internal ring of the chronic large indirect inguinal hernia. There was no evidence of any thin, ulcerated skin superficial to this ring.

The patient was surprisingly contented, albeit a little wondrous, in the presence of this rather severe pathology. After more than a little persuasion, she finally agreed to come into hospital on the understanding that she should go home on the following day but one.

AT OPERATION.—The hernia was approached by an elliptical incision, carrying a generous area surrounding it of unhealthy and almost avascular skin. The abdominal cavity was entered by the same cut, as peritoneum and skin were in effect one layer. The proximal and distal limbs of the strangulated loop were transected at a reasonable distance, and the bowel reconstituted by end-to-end anastomosis. The specimen, as shown in *Fig.* 371, was thus removed *en bloc*. There could be little thought of a repair as there was no wall to the lower two-thirds of the abdomen.

She made an uneventful recovery and was supplied with a surgical corset on discharge. Six months later she appeared perfectly contented, and the scar, together with the rest of the skin, was withstanding satisfactorily the visceral *vis a tergo*.

FIG. 371.—The specimen.

COMMENT

The possible mechanism appears to have been that of a slow and unremitting process of attrition within a loculus of her vast hernia, the neck of this

loculus being the thickened skin edge already described. Unknown to the patient, probably, the wall of this satellite hernia became thinner and thinner through the years, a process no doubt contributed to by the steady devascularizing effect of the thick, contracting ring of skin at its neck.

It is difficult to explain the absence of any signs of this ulcerated skin and peritoneum, as the abdominal wall presented a clearly punched-out deficiency filled by the loop of small bowel. A possible reason is that the sac may have finally disappeared a day or two previously, and the eventual climax came when a loop of small bowel escaped and thus became strangulated. Unfortunately the patient's awareness went back no longer than six hours.

My thanks are due to Mr. N. E. Stidolph, Whittington Hospital, for allowing me to deal with, and publish this case.

RETROMAMMARY BREAST ABSCESS

By J. S. FRASER

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ALTHOUGH abscess formation in the lactating breast is common, it is normally of the intramammary type and retromammary breast abscess is unusual. This case illustrates a breast abscess with the uncommon features of almost silent onset, retromammary position, and very large size.

CASE REPORT

HISTORY.—A woman, aged 28, para 1, after a normal pregnancy was delivered spontaneously in hospital of a healthy full-time male child. On the fifth day after birth the child developed a mild conjunctivitis of the left eye and culture of the discharge gave a pure growth of coagulase-positive *Staph. aureus* sensitive to penicillin.

FIG. 372.—Showing the extent of the enlargement of the left breast.

After four days' treatment with 10 per cent 'Albucid' drops and systemic penicillin the conjunctivitis cleared up. The mother's progress was uneventful and she was allowed home on the tenth day after delivery, breast feeding the child satisfactorily.

Seven weeks after confinement the patient reported to the post-natal clinic with the following history. Four days after discharge from hospital the left breast became a little uncomfortable and hard. On this account breast feeding was discontinued and a course of stilbœstrol started. The discomfort soon disappeared, although the size of the breast increased.

ON EXAMINATION.—The left breast, which was not tender, showed a considerable uniform enlargement, standing out 4 in. from the chest wall (*Fig.* 372). The skin was not glazed, œdematous, or reddened, nor adherent to the underlying breast tissue, and the nipple was healthy. Deep fluctuation was elicited and the breast felt as if set on a sorbo rubber base. The right breast was normal in all respects. The pulse-rate was 80 per minute, temperature 98° F., white blood-count 13,500 cells per c.mm., hæmoglobin 65 per cent (9·45 g.), red blood-count 3,960,000 per c.mm., and colour index 0·8. X-ray examination showed the left chest obscured by the enlarged breast on that side, but the lung shadows were normal and there was no evidence of bony disease.

AT OPERATION.—The breast was explored under general anæsthesia with a large-bore needle and thick yellow pus aspirated from the lower lateral quadrant. A radial incision was made in the same area and, after a large amount of pus had been evacuated, digital examination showed a massive cavity separating the breast from the chest wall. Films of the pus showed polymorphs and lymphocytes with Gram-positive bacilli but no tubercle bacilli. Culture yielded a very good growth of coagulase-positive *Staph. aureus* sensitive to penicillin. After-treatment consisted of acriflavine dressings with a course of procaine penicillin, and the purulent discharge rapidly subsided. The patient left hospital a fortnight after the operation, by which time the wound had completely healed and the indurated breast tissue had softened considerably.

COMMENT

It is surprising that, apart from initial discomfort for a few days, manifestations of inflammation were absent, for pain, tenderness, and erythema are normally marked in acute mastitis. McGuiness and Musgrove (1949) reported a few cases of abscess formation in "a breast which had at no time been especially tender or reddened and the patient's temperature had never risen above 100°", but these cases had previously been treated with penicillin or aureomycin. A relatively asymptomatic abscess is also occasionally seen following treatment with sulphonamides, but in this case there had been treatment with neither antibiotics nor sulphonamides.

The organism isolated in this instance was a coagulase-positive, penicillin-sensitive *Staph. aureus*, which is accepted as the common causative organism of acute mastitis. Walsh (1949) reported it in 56 abscesses in a series of 57 cases. The baby's inflamed eye was the probable source of the organism, but a more usual source is the child's nasopharynx, and Torrey and Reese (1945) noted it in the nasopharynx of 50 per cent of infants after the second day of life.

The incidence of abscess formation remains disappointingly high, for it had been hoped that after the introduction of penicillin suppuration could be prevented in practically all cases of acute mastitis. In most cases penicillin injections are probably not instituted sufficiently early, but Hesseltine, Freundlich, and Hite (1948) noted a significantly high resistance to penicillin among some strains of coagulase-positive *Staph. aureus*.

Few breast abscesses attain the dimensions illustrated here, and uniform enlargement of this degree is probably only seen where the abscess is retromammary in position.

I am indebted to Dr. G. P. Milne for permission to publish this case.

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STRANGULATED INGUINOFEMORAL HERNIA WITH DESCENT OF THE TESTIS THROUGH THE FEMORAL CANAL

A REPORT OF ONE CASE AND REVIEW OF THE LITERATURE

BY D. I. STIRK
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DESCENT of the testis through the femoral canal is a rare condition. Eccles in 1903 stated that the condition does not occur. Since that time descent of the testis by this route has been recorded on three occasions: Macewen (1920) and Fauntleroy (1920) operated for cure of hernia and found the inguinal canal absent and that the testis and hernia had descended through the femoral canal, the testis in both cases being in the scrotum. Pannett (1921) operated for maldescended testis and found that the testis had descended into the thigh through the femoral canal.

CASE REPORT

A male Chinese, aged 37, was admitted to the General Hospital with a tense, tender swelling in the right groin. He had been aware of a swelling in this region for fifteen or twenty years: he had had no trouble from it and the swelling always disappeared on lying down. He stated that his right testis had been absent since birth. Three days before admission, the swelling had become tender, hard, and irreducible: he had not had his bowels open for three days and had vomited about six times a day for the same period.

ON EXAMINATION.—The patient's general condition was good. No abnormalities were found in the chest or abdomen. In the inguinal region: on the left side no abnormality was detected and the left testis was in the scrotum; on the right side the right testis was not in the scrotum and was not palpable in the inguinal region. There was a tense, tender swelling below and lateral to the pubic spine.

A diagnosis of strangulated right femoral hernia was made.

AT OPERATION (Feb. 7, 1955).—The hernia was exposed through an inguinal incision. The sac was opened and found to contain strangulated, but viable, omentum and small intestine. The constriction had occurred at

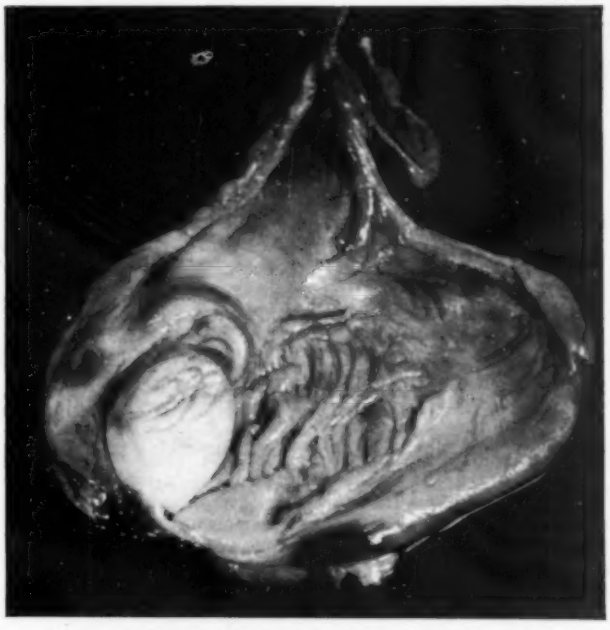

FIG. 373.—Photograph showing the hernial sac with testis and epididymis in the lateral wall, after removal. (× ⅓.)

the femoral ring. During subsequent freeing of the sac a a small, atrophic testis, with separate epididymis, was found lying closely adherent to the lateral wall of the sac. (*Fig.* 373.) Sac and attendant spermatic cord were traced through the femoral canal and along the inguinal canal to the internal ring, which was enlarged to two fingers' breadth. It was noted that there was no external abdominal ring. The sac was pulled down and tied at the internal ring, and the spermatic cord ligated and divided at the internal ring. The inguinal canal was then closed. The patient made a good recovery from operation and, when seen three months later, appeared well in all respects.

SUMMARY

A case of strangulated inguinofemoral hernia with descent of the testis through the femoral canal is reported.

The literature is reviewed.

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REVIEWS AND NOTICES OF BOOKS

Salivary Gland Tumours. By DONALD E. ROSS, M.D., F.A.C.S., F.I.C.S., F.R.C.S. (Eng. and Edin.), Chief Surgeon, Ross-Loos Medical Group, Los Angeles, California. 11 × 8¾ in. Pp. 86 + vii. Illustrated. 1955. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 54s.

THIS monograph deals with the signs, symptoms, pathology, and treatment of salivary tumours. There is nothing new in this book and the illustrations are not as good as one could wish; in fact some of them are crude. No surgeon would use this book as a reference volume.

Suprapubic Prostatectomy. With Primary Closure of the Bladder by an Original Method. By Univ. Prof. Dr. THEODOR HUYRTSCHAK, Vienna. Authorized translation by NOBLE S. R. MALUF, M.S., M.D., Ph.D., Houston, Texas. 9 × 5⅞ in. Pp. 187 + xxxii, with Frontispiece and 31 illustrations. 1955. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 61s.

IN this monograph the late Dr. Theodor Huyrtschak describes in detail the various steps of his operation for suprapubic prostatectomy. He gives the differences between his own technique and that of Harris.

An excellent chapter is devoted to cardiovascular safety, and the various tests of renal function which the author advises are detailed.

There is very little difference between the operative technique of Hey, of Manchester, and that of the author of this book.

Modern Operative Surgery. Edited by the late G. GREY TURNER, LL.D., D.Ch., M.S., F.R.C.S., F.R.A.C.S., F.A.C.S., Professor of Surgery in the University of London and Director of the Department of Surgery at the British Postgraduate Medical School; and LAMBERT CHARLES ROGERS, V.R.D., M.Sc., M.D., F.R.C.S., F.R.C.S.E., F.R.A.C.S., F.A.C.S., Professor of Surgery, University of Wales; Director of Surgical Unit, Cardiff Royal Infirmary. Fourth Edition. In two volumes. 9 × 6 in. Vol. I. Pp. 1229 + xx, with 476 illustrations. 1955. London: Cassell & Co. 70s.

WHEN the first edition of *Modern Operative Surgery* appeared in 1924 it was at once acclaimed as an excellent and reliable account of surgical procedure and technique as practised by British surgeons. Since that date three further editions have made their appearance and the last is dedicated to the memory of George Grey Turner, who edited the second and third editions and took a leading part in the preparation of this edition.

Sir Gordon Gordon-Taylor in a foreword pays fine tribute to Grey Turner, the Master Surgeon of his time.

This new fourth edition contains the names of some fourteen new contributors who, one and all, have contributed outstanding sections to this large work. Each contribution is well balanced both in content and outlook. The authors have avoided the temptation to make a mere catalogue of operations, but have given instead a detailed account of the workaday procedures of general surgical practice.

We have only one criticism to make and that is that some of the illustrations are somewhat dated and the blocks from which they have been printed are badly worn and so the production is not clear.

We are pleased to say that this new edition of *Modern Operative Surgery* is an authoritative survey of the whole field of everyday operations and is a compendium of all that is best in established British surgery. The mantle of Editorship has fallen on Lambert Rogers, and he has carried out his work in an admirable way, and one which would have pleased his friend, Grey Turner.

British Medical Bulletin. Vol. II, No. 3, Sept., 1955. **Surgery of the Heart and Thoracic Blood Vessels.** Scientific Editor: N. R. BARRETT. London: The British Council.

THIS admirable review of the present status of cardiac surgery in Great Britain can be recommended as excellent reading for surgeons who are interested in heart work and indeed for all who want to know what can and is being done at the present time.

The surgery of the heart and great vessels has made such rapid advances in recent years that anything published is likely to be out of date before it appears in print, but on this occasion Sir Russell Brock, with the assistance of Mr. N. R. Barrett, has managed to produce a thoroughly up-to-date review. There is an introductory article on anæsthesia for cardiac surgery, rightly introductory as cardiac surgery could not have made such advances without simultaneous ones in the art of anæsthesia. Drs. Maurice Campbell and Paul Wood contribute excellent essays on the selection of patients for surgery in both congenital and acquired heart disease, and there is a comprehensive collection of papers from surgeons in this country describing the particular techniques necessary in cardiac conditions which are at present amenable to surgical treatment.

In the field which may be looked on at the present time as experimental—that is the closure of septal defects and the treatment of incompetent aortic and mitral valvular disease—there are stimulating articles with

additional ones on reconstruction of the aorta, hypothermia, and the resuscitation of the heart in fibrillation and arrest. To complete this symposium, and for good measure, there is an account of the technique of cross-circulation from the pen of Andreasen, who has carried out much experimental work on this subject at the Buckston-Browne Farm. There is also a description of the artificial heart-lung which has been evolved and worked with at the Postgraduate Medical School by Cleland and Melrose.

All these articles are concise and full of excellent material, they are well illustrated, and indeed present a very good account of the state of heart surgery in this country to-day.

Breast Cancer and its Diagnosis and Treatment. By EDWARD F. LEWISON, B.S., M.D., F.A.C.S., Assistant Professor of Surgery, Johns Hopkins University School of Medicine; etc. 10 × 6¾ in. Pp. 478 + xii, with 181 illustrations. 1955. Baltimore: Williams & Wilkins Co. (London: Baillière, Tindall & Cox Ltd.) 114s.

YET another book on cancer of the breast dealing with the diagnosis and treatment of this all too common condition. It may be said at once that there is nothing new in this big volume, and a large number of photographs portray a series of inoperable cancers of the breast. The 'so-called' extended radical mastectomy has little to recommend it, as the operation cannot possibly remove all the lymphatics from the mediastinum.

The best chapter in the book is devoted to radiotherapy of breast cancer.

The chapter dealing with self examination of the breast is dangerous. If the female public of England were advised to examine their breasts every month after menstruation it would produce a vast number of cases of cancer phobia, especially if the women were asked to examine their breasts in four different positions when lying down and when standing up.

Statistics of breast cancer can be made to prove anything until the time comes when everybody dying from cancer, or from whom a cancer has been removed, is subjected to a detailed post-mortem examination; and this is not done at present in America or in England.

Thoracic Surgical Management. By J. R. BELCHER, M.S., F.R.C.S., Surgeon, London Chest Hospital; and I. W. B. GRANT, M.B. (Edin.), F.R.C.P. (Edin.), Physician, Respiratory Diseases Unit, Northern General Hospital, Edinburgh. With a Foreword by Sir CLEMENT PRICE THOMAS. Second Edition. 8 × 5¾ in. Pp. 216 + ix, with 78 illustrations. 1955. London: Baillière, Tindall & Cox Ltd. 21s.

IT is only two years since the first edition of this book appeared and the early appearance of a second edition indicates its success. It gives a full account of pre-operative and post-operative management of thoracic surgical cases which will be appreciated by all housemen and others who have to look after them.

Most of the basic matters connected with an understanding of thoracic surgical disease are also briefly presented, and this makes the book almost a practical text-book as well as a guide to management.

The recommendations are in general orthodox and acceptable, although one regrets the support of cricothyroid puncture for bronchography and also tracheal puncture for tracheal anæsthesia. Not sufficient is said about too early removal of the drainage-tube in the management of acute empyema and the causation of chronicity. Fig. 38 needs altering; it shows the head and neck too extended for efficient bronchoscopy.

Apart from these matters, the book can be strongly recommended.

The British Encyclopædia of Medical Practice. Medical Progress 1955. Editor in Chief: THE LORD HORDER, G.C.V.O., M.D., F.R.C.P. 9¾ × 6¼ in. Pp. 325 + vi. 1955. London: Butterworth & Co. (Publishers) Ltd. 35s.

THE 1955 edition of *Medical Progress* presents not only a comprehensive survey of the three major fields of medicine, surgery, and gynæcology and obstetrics, but brings up to date the knowledge accumulated in various specialities. After an introduction by the late Lord Horder, editor in chief, the book is divided into three parts: critical surveys; recent developments in drugs; and abstracts of recent literature. It is a good example of the trends of modern medicine; the marriage of the clinical sciences and specialities to the laboratory and research departments at the human level. The most striking feature is the bewildering number of new drugs that have been incorporated into modern therapy. Many of them are still in the experimental stage of trial and error and so *sub judice*, but the urge for priority is so pressing as to be open to the criticism of prematurity of publication.

However, the reader will find many of the subjects discussed from different points of view by different authors. For instance, lung surgery is discussed under the heads of general surgery, tuberculosis, and malignant disease; carcinoma mammæ with reference to bilateral adrenalectomy and oöphorectomy as well as hypophysectomy, under general surgery and malignant disease, to which Ian Aird and Ronald Raven make handsome contributions. In anæsthesia the sands are shifting from relaxant and hypotensive drugs towards hypothermia or the so-called artificial hibernation. There is an increasing demand for radiological investigations, and the use of biligrafin in cholecystography and cholangiography is discussed. Antibiotics figure largely in the chapters on medicine and tuberculosis, as cortisone therapy does in those on endocrinology, ophthalmology, dermatology, and medicine.

The replacement of the cataract lens by a plastic one and the isolation of alderstone—an adrenal tumour secreting it having already been removed—call for special comment.

It would perhaps be invidious in this journal to single any of the other names from such a distinguished team of contributors, when each article bears the hall mark of high authority, and many references.

For those who wish to be *au fait* with current medical opinion, literature, and research, this book can be strongly recommended.

Cardiac Anomalies. A Clinicopathologic Correlation. By VINCENT MORAGNES, M.D., Associate Professor of Pathology, Creighton University School of Medicine, Omaha, Nebr.; and CHESTER P. LYNXWILER, M.D., Assistant Professor of Pediatrics, St. Louis University School of Medicine, St. Louis. 11 × 8½ in. Pp. 92 + x, with 157 illustrations. 1954. Baltimore: Williams & Wilkins Co. (London: Baillière, Tindall & Cox Ltd.) $6.50.

IN this beautifully and spaciously produced volume the authors have grouped a series of cardiac anomalies under a morphological classification, photographs of specimens, radiographs, and electrocardiograms being used as examples, and each anomaly being "covered with brief statements regarding pathology, course of circulation, clinical features, laboratory findings, electrocardiography and radiological studies, prognosis, as well as medical and surgical treatment" and histological findings.

As a whole the descriptions are too detailed for undergraduate requirements and too brief and too stereotyped for the serious inquirer, and give little help in differential diagnosis and special investigation. The radiographs, though described as "A.P roentgenograms" are clearly

P.A. films of generally poor quality. There is one angiocardiogram. The E.C.G. tracings (standard leads only) are sometimes inadequately labelled (Fig. 2) and of varying quality.

It is notoriously difficult to illustrate this subject by photographs of specimens, and even where the depth of focus and reproduction is satisfactory, it is sometimes impossible for an experienced reader to interpret the photograph, even with the aid of the legend (e.g., coarctation of the aorta). The few clear anatomical diagrams are of much greater service. It is unfortunate that on many occasions the specimens chosen to illustrate the text do not reproduce the features listed (e.g., in V.S.D.).

The subject-matter is on the whole good, and with a brief text there are bound to be omissions; but on occasion these can be misleading, as for example the text (p. 21) suggests that tricuspid atresia is always accompanied by a patent ductus arteriosus, and (p. 51) that the use of angiocardiogram in Tetralogy of Fallot is to show the side of the aorta. The arrangement gives no idea of the relative frequency or practical importance of the various malformations. The book is devoid of references apart from acknowledgment of illustrations.

This book is a prettily illustrated collection of cardiac anomalies, rare and common, within the experience of the authors; its value apart from this is strictly limited.

The Spine. A Radiological Text and Atlas. By BERNARD S. EPSTEIN, M.D., Chief, Department of Radiology, The Long Island Jewish Hospital, New Hyde Park, New York. 10 × 7 in. Pp. 539, with 721 illustrations. 1955. London: Henry Kimpton. £6.

THIS is a large comprehensive volume consisting of some 721 illustrations and an excellent lucid description of the common and uncommon conditions met with in the spinal column. The radiographs throughout the work are good and do enhance the value of the book.

It is true, as the author remarks in the preface, that much of the radiology of the spine has appeared in specialized journals and is therefore not necessarily seen by the orthopædic surgeon, neurologist, pædiatrician, and anatomist. This volume certainly fills a want in medical literature. The chapter on the normal spine is a model of interest and anatomical detail as revealed in a series of radiographs.

Myelography and discography are considered in detail, while malformations of the spinal column are excellently described and illustrated.

Neoplasms of the vertebral column and spinal traumatic changes and diseases of the intravertebral disks are dealt with in a masterly fashion.

This book will long remain the reference volume dealing with the X-ray examination of the spine.

Christopher's Minor Surgery. Seventh edition. Edited by ALTON OCHSNER, M.D., F.A.C.S., William Henderson Professor of Surgery, Tulane University of Louisiana School of Medicine; and MICHAEL E. DEBAKEY, M.D., F.A.C.S., Professor of Surgery, Baylor University College of Medicine. 9 × 6¾ in. Pp. 547 + xvi, with 251 illustrations. 1955. Philadelphia and London: W. B. Saunders Co. 63s.

A NEW edition of this well-known text-book is assured of a welcome. It is only seven years since the sixth edition appeared, but so many alterations have been required to keep the work up to date that this is to all intents and purposes a new text-book of surgery, written by a large team of specialists and ably edited by Ochsner and DeBakey. There is no question about the competence of their collaborators, but it is clear that one of the difficulties the editors have had to contend with has been a tendency for some authors to stray beyond the confines of what may be properly regarded as 'minor surgery'. In their preface they try to make excuse for this lack of uniformity by saying that minor surgery is difficult to define—and so it is. Clearly the title has to be retained in honour of Dr. Christopher, but they must have been sorely tempted to call it 'A Text-book of Surgery', which might be a better description of most of its contents.

The early chapters are written for the young Resident and are of real value to the man who is looking for advice in performing minor operations, and the same may be said of several of the other chapters, particularly those on the anal region, burns, infections, injuries, and the male genital organs. But some of the material in the chapters on the vascular and nervous systems, the deformities, tumours, and anomalies, can only be described as major surgery. This is not a criticism of the quality of the work, which is excellent, but only of its content, and even as we make the criticism we offer the editors our sympathy as well as our commendation. The book is very well illustrated and should be greatly valued by students and house officers.

The Diagnosis and Treatment of Hæmophilia and its Related Conditions. By R. G. MACFARLANE, M.D., and ROSEMARY BIGGS, M.D. *Medical Research Council Memorandum*, No. 32. 9½ × 6 in. Pp. 23 + viii. 1955. London: Her Majesty's Stationery Office. 2s. 6d.

THIS short memorandum covers the up-to-date knowledge of hæmophilia and the related bleeding conditions. A short introduction on the mechanism of blood-clotting is followed by chapters on clinical and laboratory diagnosis, and finally a chapter on treatment tells us what can be done for these unfortunate people. There is valuable information here for the physician, the pathologist, and the surgeon.

Figures suggest that there are between 400 and 800 true hæmophiliacs in England and Wales, so the problem affects only a few patients, but for them it is a matter of life or death, and the emergency of dealing with a bleeder is one with which any doctor is likely to be faced at some time in his career. Here is given clearly and briefly all the information available on the subject and it should be read by all clinicians and pathologists. It is helpful to know that Russell's viper venom or thrombin applied locally will coagulate hæmophilic and Christmas disease blood as readily as normal blood. To the surgeon, however, the advice is unequivocal, to avoid these patients unless operation " is considered essential for the patient's survival ".

The Mechanisms of Healing in Human Wounds. A Correlation of the Clinical and Tissue Factors involved in the Healing of Human Surgical Wounds, Burns, Ulcers, and Donor Sites. By SHATTUCK W. HARTWELL, B.S., M.S., M.D., Ph.D., F.A.C.S., F.I.C.S. *American Lecture Series*, No. 250. 8½ × 5½ in. Pp. 166 + xii, with 44 illustrations. 1955. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 34s.

THE problem of how wounds heal has interested the medical profession for centuries and many and varied accounts of this process have been forthcoming over the years.

Dr. Hartwell has studied the healing processes in the human subject for many years and has written extensively on this matter. He has now published all his investigations in a monograph; he was the first to differentiate between epithelial and fibrous healing of wounds.

The present monograph makes interesting reading, but there is no reference to the work of the British plastic surgeons and their researches, which during and after the second world war have contributed so much to our knowledge of the healing of wounds and burns.

Textbook of Surgery. Edited by H. F. MOSELEY, M.A., D.M., M.Ch. (Oxon.), F.A.C.S., F.R.C.S. (Eng.), F.R.C.S. (C.), Assistant Professor of Surgery, McGill University; Associate Surgeon, Royal Victoria Hospital, Montreal, Canada. With a Foreword by G. GAVIN MILLER. Second edition. 10 × 6¾ in. Pp. 1136 + xxiv, with 571 illustrations and 79 coloured plates. 1955. St. Louis: C. V. Mosby Co. (London: Henry Kimpton.) £6.

THAT a second edition of this work was required within three years is no surprise to British surgeons, for the first edition was popular from its publication. This text-book reveals the McGill system of surgical teaching and operative technique, which is excellent. The work is comprehensive, up to date, well written, and the illustrations, which are numerous, are excellent.

It is a pity that the publishers have not insisted on two volumes which make for more comfort to the reader, as this one volume of some 1136 pages is very heavy and can only be read while sitting at a desk or table.

This Canadian surgery has taken a high place in the world literature dealing with medical science.

A Short Textbook of Surgery. By C. F. W. ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S. (Edin.), F.R.F.P.S. (Glas.), Hon. F.A.C.S., Regius Professor of Surgery, University of Glasgow. Sixth edition. 9¼ × 6 in. Pp. 628 + viii, with 233 illustrations and 13 plates. 1955. London: J. & A. Churchill Ltd. 37s. 6d.

THE sixth edition of this well-known text-book has been very thoroughly revised and brought up to date. Professor Illingworth is to be congratulated upon still maintaining the lead by writing the best shorter text-book of surgery in the English language.

Surgery of the Stomach and Duodenum. By CLAUDE E. WELCH, M.D., D.Sc. (Hon.), Visiting Surgeon, Massachusetts General Hospital; Clinical Associate in Surgery, Harvard Medical School. Second edition. 8¼ × 5¼ in. Pp. 370, with 79 plates of illustrations by Muriel McLatchie Miller. 1955. Chicago: The Year Book Publishers Inc. (London: Interscience Publishers Ltd.) 68s.

THE second edition of this popular little monograph has been somewhat extended and several new plates have been included. There can be little doubt that the admiration that students and the younger surgeons have for this book is due to two things: One, the lucid way in which the text is written; and, two, the simplicity and excellence of the illustrations.

Introduction to Hepatic Surgery. By HENRY GANE, M.D., Surgical Resident, Cincinnati, Ohio; with an Introduction by A. BRUNSCHWIG, M.D. 8¼ × 7⅞ in. Pp. 265 + xvi, with 120 illustrations. 1955. Amsterdam and New York: Elsevier Publishing Co. (London: Cleaver-Hume Press, Ltd.) 70s.

THIS appears to be the first book which has been devoted to the subject of hepatic surgery, and it is indeed both interesting and provocative. After dealing with the anatomy and the embryology of the liver, the author considers in detail the various indications for hepatic surgery and the care of the patient before, during, and after hepatic surgery.

Hepatography is described in detail and pros and cons of this procedure are discussed.

One is rather disappointed that the author does not describe in detail the various operative procedures that are undertaken for the removal of hepatic growths—after all, except for traumatic cases, it is the primary growths of the liver that make up a considerable part of hepatic surgery.

Transplantation of Tissues. Cartilage, Bone, Fascia, Tendon, and Muscle. By LYNDON A. PEER, M.D., Clinical and Research Director, Rehabilitation Center for Plastic and Reconstructive Surgery, St. Barnabas Hospital, Newark, N.J. 10 × 6⅝ in. Vol. I. Pp. 421 + xii with 163 illustrations. 1955. Baltimore: The Williams & Wilkins Co. (London: Baillière, Tindall & Cox Ltd.) 102s. 6d.

THIS large monograph is certainly abreast of the times and surgical replacement therapy has come into its own. Dr. Peer is the inventor of diced cartilage grafts, which can to-day be used for curing many bony defects. The use of dried cartilage grafts to form new ribs for the thoracic cage is a great step forward. This book reveals a new surgical era—namely, the transplantation of various kinds of tissues, heterogenous, homogenous, and autogenous, into animals and man. There is scarcely a single branch of surgery to-day where some form of transplantation of tissues is not being undertaken.

Dr. Peer has made use of his immense amount of material in presenting this book and there can be little doubt that it will be the reference volume on the subject of transplantation of tissues for many years to come.

The present volume deals with cartilage, bone, fascia, tendon, and muscle, and the second volume, which we all hope to see, will consider the various additional aspects of cell structure and cell behaviour.

An excellent production with first-class illustrations.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]

Arthroplasty. By ST. J. D. BUXTON, M.B., B.S., F.R.C.S., Consulting Orthopædic Surgeon to King's College Hospital, etc. 8½ × 5½ in. Pp. 126 + viii, with 43 illustrations. 1955. London: Pitman Medical Publishing Co., Ltd. 30s.

Living Bone in Health and Disease. By IRVIN STEIN, A.B., M.D., F.A.C.S., F.I.C.S., Assistant Professor of Orthopedic Surgery, University of Pennsylvania, etc.; RAYMOND O. STEIN, A.B., M.D., F.I.C.S., Assistant in Orthopedics, Hahnemann Medical School; and MARTIN L. BELLER, A.B., M.D., Instructor in Orthopedics, Hahnemann Medical School. 10 × 7 in. Pp. 510 + xii, with 387 illustrations. 1955. London: Pitman Medical Publishing Co., Ltd. £5 10s.

Blood Transfusion. A Guide to the Practice of Transfusion within Hospitals. By GEORGE DISCOMBE, M.D., B.Sc. (Lond.), Pathologist, Central Middlesex Hospital. 7¼ × 4¾ in. Pp. 64. 1955. London: William Heinemann (Medical Books), Ltd. 6s.

Ear, Nose and Throat Nursing. By F. BOYES KORKIS, M.B., Ch.B., D.L.O., F.R.C.S., F.I.C.S., Surgeon, Metropolitan Ear, Nose, and Throat Hospital. 8 × 5⅜ in. Pp. 168 + viii, with 85 illustrations. 1955. London: J. & A. Churchill Ltd. 12s. 6d.

Text-book of Orthopædic Medicine. By JAMES CYRIAX, M.D., M.R.C.P., Physician to the Department of Physical Medicine, St. Thomas's Hospital, London. Fifth edition. Vol. I. Treatment by Manipulation and Massage. 8½ × 5½ in. Pp. 373 + xvi with 127 illustrations. 1955. London: Cassell & Co., Ltd. 21s.

Subphrenic Abscess. By H. R. S. HARLEY, M.S., F.R.C.S., Consultant Thoracic Surgeon to the United Cardiff Hospitals and to the Welsh Regional Hospital Board. 8½ × 5½ in. Pp. 216 + xii, with 41 illustrations. 1955. Oxford: Blackwell Scientific Publications. 35s.

Understanding Surgery. Edited and compiled by Dr. ROBERT E. ROTHEMBERG. 6¾ × 4⅛ in. Pp. 620 + xx, with 103 illustrations by Sylvia and Lester V. Bergman. 1955. New York: Pocket Books, Inc. (Leicester: Thorpe & Porter Ltd.) Cardinal Giant edition, 3s. 6d.

The Pregnancy Toxæmias or the Encymonic Atelositesis. By G. W. THEOBALD, M.A., M.D., F.R.C.S. (Edin.), F.I.C.S., F.R.C.O.G., M.R.C.P. (Lond.), Hon. Obstetrician and Gynæcologist to St. Luke's Maternity Hospital, St. Luke's Hospital, and the Royal Infirmary, Bradford; etc. With a Chapter on the Adrenal Cortex by JOHN DAWSON, M.B., Ch.B., M.Sc. (Leeds), Lecturer in the Department of Biochemistry, Leeds University. 9⅛ × 6⅛ in. Pp. 488 + xiv, with 50 illustrations. 1955. London: Henry Kimpton. 63s.

Local Analgesia: Head and Neck. By Sir ROBERT MACINTOSH, D.M., F.R.C.S. (Edin.), F.F.A.R.C.S., Nuffield Professor of Anæsthetics, University of Oxford; and MARY OSTLERE, M.B., M.R.C.P.E., F.F.A.R.C.S., Research Assistant, Nuffield Department of Anæsthetics, University of Oxford. 8⅝ × 5⅞ in. Pp. 138 + viii, with 145 illustrations by Marjorie Beck, some coloured. 1955. Edinburgh: E. & S. Livingstone Ltd. 27s. 6d.

Surgery of the Ambulatory Patient. By L. KRAUR FERGUSON, M.D., F.A.C.S., Professor of Surgery, University of Pennsylvania; etc. With a section on Fractures by LOUIS KAPLAN, M.D., F.A.C.S., Senior Attending Surgeon, Albert Einstein Medical Center, Southern Division; etc. Third edition. 9 × 6 in. Pp. 866 + xxvii, with 664 illustrations. 1955. Philadelphia: J. B. Lippincott Co. (London: Pitman Medical Publishing Co. Ltd.) 96s.

Proctologic Anatomy. By R. V. GORSCH, A.B., M.D., F.I.C.S., F.A.P.S., D.A.B.P., Clinical Professor of Proctology, New York Polyclinic Medical School and Hospital. Second edition. 9 × 6 in. Pp. 310 + xvi, with 155 illustrations. Baltimore: Williams & Wilkins Co. (London: Baillière, Tindall & Cox Ltd.) 61s. 6d.

Traité de Technique Chirurgicale. By MM. B. FEY, P. MOCQUOT, S. OBULIN, J. QUÉNU, P. TRUFFERT, M. DAVID, M. ISELIN, R. DOSSOT, R. DUBAN, CH. DUBOST, J.-J. GALEY, Y. LONGNET, J. LOYGNE, J. MATHEY, F. PALMER, J. PERROTIN, J. RUDLER, G. THOMERET, and J. VARANGOT. Second edition, completely revised, in 8 volumes. 9½ × 6¾ in. Vol. IV. Poumon—Cœur—Paroi thoracique. Pp. 1330 + viii, with 864 illustrations. 1955. Paris: Masson et Cie. 8800 fr.

Roentgen Interpretation. By GEORGE W. HOLMES, M.D., Hon. Physician, Massachusetts General Hospital, etc.; and LAURENCE L. ROBBINS, Radiologist in Chief to the Massachusetts General Hospital; etc. Eighth edition. 9¼ × 6 in. Pp. 525, with 371 illustrations. 1955. London: Henry Kimpton. 72s. 6d.

Diseases of the Nose and Throat. A Textbook for Students and Practitioners. By Sir ST. CLAIR THOMSON, M.D., F.R.C.P., F.R.C.S. Revised by V. E. NEGUS, D.Sc., M.S., F.R.C.S., Consulting Surgeon for Diseases of the Ear, Nose, and Throat, King's College Hospital; with the assistance of G. H. BATEMAN, M.A., B.M., B.Ch., F.R.C.S., Surgeon to the Ear, Nose, and Throat Department, St. Thomas's Hospital, London. Sixth edition. 9¼ × 6¼ in. Pp. 1040 + xvi, with 46 Plates, some coloured, and 353 illustrations. 1955. London: Cassell & Co. Ltd. 90s.

Fractures of the Facial Skeleton. By N. L. ROWE, F.D.S. R.C.S., L.R.C.P., M.R.C.S., L.M.S.S.A., H.D.D. R.C.S., and H. C. KILLEY, F.D.S. R.C.S., L.R.C.P., M.R.C.S., L.M.S.S.A., H.D.D. R.C.S., Consultants in Oral Surgery, Plastic and Maxillo-facial Surgery Unit, Rooksdown House, Basingstoke. With a Foreword by Sir REGINALD WATSON-JONES. 9¾ × 6¾ in. Pp. 923 + xxxvi, with 1231 illustrations, 14 in colour. 1955. Edinburgh: E. & S. Livingstone Ltd. £6.

The Boke of Chyldren. By THOMAS PHAIRE (1510-1560). 7¼ × 4¾ in. Pp. 76. 1955. Edinburgh: E. & S. Livingstone Ltd. 7s. 6d.

Body Fluids in Surgery. By A. W. WILKINSON, Ch.M., F.R.C.S.E., Senior Lecturer in Surgery, University of Aberdeen; etc. 8½ × 5½ in. Pp. 212 + x, with 6 illustrations. 1955. Edinburgh: E. & S. Livingstone Ltd. 16s.